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GEORGICAL ESSAYS:

BY

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Nisi utile est quod facimus stulta est gloria.

Phaedr.

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THE whole impreſſion of theſe Eſſays in ſmall Octavo being ſold off, the Editor has been adviſed to reprint them in the preſent form. This volume contains ſeveral additional papers, which may be had ſeparate for the convenience of ſuch Gentlemen as have done honour to the Editor by purchaſing the former Edition in four volumes. The work will probably be continued.

GEORGICAL ESSAYS.

BOOK I.

The Riſe and Progreſs of Agriculture.

AGRICULTURE is the oldeſt, as well as the moſt uſeful, of the arts. In the ſacred writings we are told that Cain applied himſelf to huſbandry, while Abel followed the peaceable life of a ſhepherd. The Patriarchs and their deſcendants ſpent their days in feeding of flocks and tilling the ground: but in thoſe early ages the art was as ſimple as the manners of the people. They lived a wandering ſort of life. Every new ſituation afforded them preſent ſupport for their flocks; and whenever they met with a fruitful piece of ground, they uſually reſted upon it, and ſowed their corn, which having reaped, they moved forward in queſt of another habitation. This was the ſtate of Agriculture when men had no other laws but thoſe of God and nature.

Among the Egyptians, a civilized nation, huſbandry was regularly attended to; and it is extremely probable that the children of Iſrael, before they left that country, had made themſelves, in ſome degree, acquainted with the manner of raiſing corn, and afterwards preſerving it. As ſoon as their deſcendants had obtained the full and quiet poſſeſſion of the promiſed land, they proceeded upon the plan of the old inhabitants, and became huſbandmen.——Every man's poſſeſſion having been allotted to him, Agriculture ſeems to have flouriſhed amongſt them, otherwiſe the land of Judea could not poſſibly have maintained the number of inhabitants that are recorded.

If we may credit the report of travellers, the land of Canaan is at preſent a barren and uncultivated country. The figurative expreſſion of a land flowing with *milk* and *honey*, ſprung from the induſtry of the inhabitants co-operating with the natural fertility of the ſoil. It was in vain for the huſbandman to expect a ſpontaneous growth of corn in the beſt of climates.

The land of Promiſe was poſſeſſed by a number of different nations. Among theſe the

Phœnicians, or Philiſtines, as they are called, were the richeſt and moſt induſtrious. They occupied a well-cultivated country bordering upon the ſea. By means of their ſkill in navigation, they exchanged the ſuperfluous product of their lands with the neighbouring nations. Their extenſive commerce is ſufficiently known. Being at laſt driven from their native country, they directed their courſe to the Mediterranean iſlands, and carried with them the art of huſbandry.

In conſequence of this migration, Agriculture became more diffuſed, and ſpread its influence over the neighbouring nations.

Hiſtory informs us that the Greeks were once a moſt barbarous people. Pelaſgus received divine honours for teaching them the uſe of acorns for food. A ſmall colony from Egypt, or Phœnicia, inſtructed them in the manner of growing corn. The Athenians were the firſt that received the ineſtimable bleſſing. Humanity ſucceeded; and from that ſource the fine arts derived their origin.

The Romans had a laudable pride in being thought huſbandmen. As early as the reign of Numa, public encouragement was given to Agriculture. Succeeding ages continued ſenſible of its utility. Sound policy informed them, that an extenſive territory and a number of inhabitants did not always conſtitute a great and powerful people. They knew that the lands muſt be cultivated, and the inhabitants muſt be induſtrious, before that deſirable event could be accompliſhed. When the Romans made the moſt illuſtrious appearance, huſbandry was in the higheſt eſtimation amongſt them. "In thoſe happy days," ſays Pliny, "the "Earth, pleaſed at ſeeing herſelf cultivated by "victorious hands, ſeemed to make ſtronger "efforts, and to produce her fruits in greater "abundance."—But when deſtructive luxury was introduced, then huſbandry declined, and with it fell all the Roman virtue.

The ancient writers give us excellent comments upon the huſbandry of their times. Heſiod wrote very early upon Agriculture. Mago, the Carthaginian General, compoſed twenty-eight books upon the ſame ſubject, which were tranſlated by order of the Roman Senate. Upon theſe models Virgil formed his elegant precepts of huſbandry. Cato, the Cenſor, wrote a volume upon Agriculture. Columella has left us twelve books upon rural matters. Varro's treatiſe will ever be eſteemed.——Many other Greek and Latin authors might be produced; but theſe will be ſufficient to ſhew, that Agriculture has ever been attended to by the wiſe Philoſopher and the good Citizen.

The celebrated Sully calls Agriculture one of the breaſts from which the ſtate muſt draw its nouriſhment. That great man could not poſſibly have given us a more happy ſimile. Inſtructing by precepts, and ſtimulating by rewards, he prevailed upon his countrymen to cultivate the art; but their induſtry was of ſhort duration. The public troubles ſoon put an end to Arts, Agriculture, and Commerce.—Colbert entertained a different notion of policy. Eſteeming Manufactures and Commerce as the ſinews of the ſtate, he gave all poſſible encouragement to the Artizan and the Merchant,—but forgot that the Manufacturer muſt eat his bread at a moderate price. The Farmer being diſcouraged, the neceſſaries of life became dear; the public granaries were ill ſtored;—manufactures languiſhed;—commcerce drooped;—a numerous army ſoon conſumed the ſcanty harveſt;—and, in a ſhort time, Induſtry fell a ſacrifice to the ill-judged policy of the Miniſter.

From that period to the preſent, the French nation have conſtantly been availing themſelves of their miſtake. Under the genial influence of the King, Societies are erected in every Province. Men of the firſt diſtinction do not diſdain the cultivation of their own lands. M. de Chateauvieux and Duhamel are the greateſt ornaments of their country.——Let us imitate the virtues of that faſhionable nation. As we have often vanquiſhed them in the field of battle, let us put our hands to the plow, and overcome them in the field of induſtry. Such purſuits have graced the public life of ancient heroes. May they be recorded in the Annals of a Britiſh King.

ESSAY I.

On the Nouriſhment of Vegetables.

THE art of Huſbandry boaſts an origin coëval with the human race. Its age, however, ſeems to have contributed but little towards its advancement, being at preſent extended but a few degrees beyond its primitive inſtitution.

Until the Philoſopher condeſcends to direct the plow, Huſbandry muſt remain in a torpid ſtate. It is the peculiar happineſs of this age, that men of a liberal education begin to cultivate this art with attention. We cannot ſay too much in praiſe of the reſpective ſocieties lately eſtabliſhed in this iſland, and in France, for the improvement of Agriculture. They have raiſed a noble ſpirit of emulation among our country gentlemen and ſenſible farmers. Each ſeems envious of contributing ſomething towards the general ſtock of knowledge. Such a pleaſing intercourſe cannot fail of ſpreading the improvements in Agriculture over the moſt diſtant parts of this iſland.

I take upon me to ſay, that, to be a good huſbandman, it is neceſſary to be a good chymiſt. Chymiſtry will teach him the beſt way to prepare nouriſhment for his reſpective crops, and, in the moſt wonderful manner, will expoſe the hidden things of nature to his view. The principles of Agriculture depend greatly upon chymiſtry: and without principles, what is art, and what is ſcience?

It is alſo neceſſary for the huſbandman to be a good mechanic, in order to be a judge of the inſtruments employed in dividing and looſening the ſoil; an operation of the greateſt uſe to the farmer.

The ingenious Dr. Home has opened to our view a noble field for improvement. His reaſoning is juſt and concluſive; but it were to be wiſhed that his experiments had been conducted upon a larger ſcale. However, contracted as they are, they will be found of great uſe to whoever intends to purſue the ſtudy of Agriculture upon rational principles.

As I intend the nouriſhment of plants to be the ſubject of this eſſay, it will be proper to obſerve, that I have been directed in my reſearches by a ſtrict attention to the analogy that ſubſiſts between animals and vegetables. We know that neither of them can ſubſiſt long without air and nouriſhment. Directed by inſtinct, the animal ſeeks its own proper food; but the vegetable, not being poſſeſſed of the power of motion, muſt be ſatisfied with the nouriſhment that we give it.

To direct this upon rational principles, is the buſineſs of the philoſopher. The practical farmer will ſuffer himſelf to be inſtructed, as ſoon as he perceives the practice correſpond with the theory laid down to him. Let us expect no more from him. Men of a limited education commit great errors when they attempt to reaſon upon ſcience. In huſbandry, effects are conſtantly applied to improper cauſes. Hence proceed the errors of our common farmers. To overcome theſe is the peculiar province of the Philoſopher; who, in his turn, muſt ſupport his reaſoning by facts and experiments.

I lay it down as a fundamental maxim, that all plants receive their principal nouriſhment from oily particles incorporated with water, by means of an alkaline ſalt or abſorbent earth.

Till oil is made miſcible, it is unable to enter the radical veſſels of vegetables; and, on that account, providence has bountifully ſupplied all natural ſoils with chalky or other abſorbent particles. I ſay natural ſoils, for thoſe which have been aſſiſted by art are full of materials for that purpoſe; ſuch as lime, marl, ſoap-aſhes, and the volatile alkaline ſalt of putrid dunghills.

It may be aſked, whence do natural ſoils receive their oily particles? I anſwer, the air ſupplies them. During the ſummer months, the atmoſphere is full of putrid exhalations ariſing from the ſteam of dunghills, the perſpiration of animals and ſmoak. Every ſhower brings down theſe oleaginous particles for the nouriſhment of plants.

When they happen to fall upon a very ſandy ſoil, the ſolar heat exhales the moſt of them. Hence an additional reaſon for covering our light ſoils with herbage during the ſummer months.

On the contrary, when theſe particles fall upon ſtiff land, or ſuch as have been marled or limed, an intimate union is produced, too ſtrong for the natural heat to reſolve.

It is obſerved, that lime mechanically binds a hot ſandy ſoil. We now ſee that it alſo fertiliſes it; but the farmer muſt not preſume too much upon that quality.

The ingenious Mr. Tull, and others, have contended for earth's being the food of plants. If ſo, all ſoils equally tilled would prove equally prolific. The increaſed fertility of a well-pulveriſed ſoil, induced him to imagine that the plow could ſo minutely divide the particles of earth, as to fit them for entering into the roots of plants.

An open ſoil, if not too light in its own nature, will always produce plentiful crops. It readily receives the air, rains, and dews into its boſom, and at the ſame time gives the roots of plants a free paſſage in queſt of food. This is the true reaſon why land well tilled is ſo remarkably fruitful.

Water is thought, by ſome, to be the food of vegetables, when in reality it is only the vehicle of nouriſhment.—Water is an heterogeneous fluid, and is no where to be found pure. It always contains a ſolution of animal or vegetable ſubſtances. Theſe conſtitute the nouriſhment of plants, and the element in which they are minutely ſuſpended, acts only as a vehicle, in guiding them through the fine veſſels of the vegetable body.

The hyacinth, and other bulbous roots, are known to perfect their flowers in pure water. Hence ſuperficial obſervers have drawn an argument in favour of water being the food of vegetables. But the truth is, the roots, ſtem, and flowers of ſuch plants are nouriſhed by the mucilaginous juices of the bulb, diluted by the ſurrounding water. This mucilage is juſt ſufficient to perfect the flower—and no more. Such a bulb neither forms ſeeds, nor ſends forth off-ſets. At the end of the ſeaſon, it appears weak, ſhrivelled, and exhauſted, and is rendered unfit to produce flowers the ſucceeding year. A root of the ſame kind, that has been fed by the oily and mucilaginous juices of the earth, eſſentially differs in every particular. It has a plump appearance, is full of mucilage—with off-ſets upon its ſides.

All rich ſoils, in a ſtate of nature, contain oil; and in thoſe lands which have been under the plow for ſome years, it is found in proportion to the quantity of putrid dung that has been laid upon them, making an allowance for the crops they have ſuſtained.

To ſet this matter in a clearer light, let us attend to the effects of manures of an oily nature, and we ſhall ſoon be ſatisfied that oil, however modified, is one of the chief things concerned in vegetation.

Rape-duſt, when laid upon land, is a ſpeedy and certain manure, though an expenſive one, and will generally anſwer beſt on a limeſtone land, or where the ſoil has been moderately limed.

This ſpecies of manure is much eſteemed by the farmer. It contains the food of plants ready prepared; but as it is not capable of looſening the ſoil by any fermentation, the lands upon which it is laid ought to be in excellent tilth. At preſent, that uſeful article of huſbandry is much diminiſhed in goodneſs, owing to the improved methods of extracting the oil from the rape. Heat and preſſure are employed in a double degree, and every other method is uſed to the prejudice of the farmer. He has, however, an honeſt remedy at hand. Let him grow his own ſeed; which, when bruiſed, to prevent vegetation, may be ſown upon his lands. By that means he will be enabled to keep his fields in heart, and ſecure to himſelf an increaſe proportionable to his expence.

Farmers that live in the neighbourhood of large towns uſe abundance of ſoot. It is an oily manure, but different from the former, containing alkaline ſalt in its own nature, calculated as well for opening the ſoil, as for rendering the oily parts miſcible with water.

It is obſerved that pigeons dung is a rich and haſty manure. Theſe animals feed chiefly upon grains and oily ſeeds; it muſt therefore be expected that their dung ſhould contain a large proportion of oil.

The dung of ſtable-kept horſes is alſo a ſtrong manure, and ſhould not be uſed until it has undergone the *putrid ferment*, in order to mix and aſſimilate its oily, watery, and ſaline parts. Beans, oats, and hay, contain much oil. The dung of horſes, that are kept upon green herbage, is of a weaker kind, containing much leſs oil. Swines dung is of a ſaponaceous and oily nature, and perhaps is the richeſt of the animal manures. When made into a compoſt and applied with judgment, it is excellent for arable lands.

The dung of ruminant animals, as cows and ſheep, is preferable to that of horſes at graſs, owing to the quantity of animal juices mixed with their food in chewing. And here I beg leave to remark in general, that the fatter the animal, *cæteris paribus*, the richer the dung.

Human ordure is full of oil and a volatile alkaline ſalt. By itſelf, it is too ſtrong a manure for any land; it ſhould therefore be made into a compoſt before it is uſed. The dung of carnivorous animals is plentifully ſtored with oil. Animals that feed upon ſeeds and grains come next, and after them follow thoſe which ſubſiſt upon graſs only.

To ſuit theſe different manures to their proper ſoils, requires the greateſt judgment of the farmer; as what may be proper for one ſoil, may be highly detrimental to another.

In order to ſtrengthen my argument in favour of oil being the principal food of plants, I muſt beg leave to obſerve, that all vegetables, whoſe ſeeds are of an oily nature, are found to be remarkable impoveriſhers of the ſoil, as hemp, rape, and flax; for which reaſon, the beſt manures for lands worn out by theſe crops, are ſuch as have a good deal of oil in their compoſition; but then they muſt be laid on with lime, chalk, marl, or ſoap-aſhes, ſo as to render the oily particles miſcible with water.

The book of nature may be diſplayed, to ſhew that oily particles conſtitute the nouriſhment of plants in their embryo ſtate; and, by a fair inference, we may ſuppoſe that ſomething of the ſame nature is continued to them as they advance in growth. The oily ſeeds, as rape, hemp, line, and turnip, conſiſt of two lobes, which, when ſpread upon the ſurface, form the ſeminal leaves. In them the whole oil of the ſeed is contained. The moiſture of the atmoſphere penetrates the cuticle of the leaves, and, mixing with the oil, conſtitutes an emulſion for the nouriſhment of the plant. The ſweetneſs of this balmy fluid invites the fly, againſt which no ſufficient remedy has, as yet, been diſcovered. The oleaginous liquor being conſumed, the ſeminal leaves decay, having performed the office of a mother to her tender infant. To perſons unacquainted with the analogy between plants and animals, this reflection will appear ſtrange. Nothing, however, is more demonſtrable.

The leguminous and farinaceous plants keep their placenta, or ſeminal leaves, within the earth; in which ſituation they ſupply the tender germ with oily nutriment, until its roots are grown ſufficiently ſtrong to penetrate the ſoil.—The curious reader will find this ſubject treated of at large in the third eſſay.

It is uſual to talk of the ſalts of the earth; but chymiſtry has not been able to diſcover any ſalts in land which has not been manured, though oil may be readily obtained from every ſoil, the very ſandy ones excepted.

Marl, though a rich manure, has no ſalts. It is thought to contain a ſmall portion of oleaginous matter, and an abſorbent earth, of a nature ſimilar to limeſtone, with a large quantity of clay intermixed.

Lime mixed with clay comes neareſt to the nature of marl of any factitious body that we know of, and may be uſed as ſuch, where it can be had without much expence. By increaſing the quantity of clay, it will make an excellent compoſt for a light ſandy ſoil; but to make the ground fertile, woollen rags, rotten dung, or any oily manure, ſhould be incorporated with it ſome time before it is laid on.

It is a received opinion, that lime enriches the land it is laid upon, by means of ſupplying a ſalt fit for the nouriſhment of plants; but by all the experiments that have been made upon lime, it is found to contain no kind of ſalt. Its operation therefore ſhould be conſidered in a different light. By the fermentation that it induces, the earth is opened and divided, and, by its abſorbent and alkaline quality, it unites the oily and watery parts of the ſoil. It alſo ſeems to have the property of collecting the acid of the air, which it readily forms into a neutral ſalt, of great uſe in vegetation.

From viewing lime in this light, it is probable that it tends to rob the ſoil of its oily particles, and in time will render it barren, unleſs we take care to ſupport it with rotten dung, or other manures of an oily nature.

As light ſandy ſoils contain but a ſmall portion of oleaginous particles, we ſhould be extremely cautious not to overdo them with lime;

unleſs we can at the ſame time aſſiſt them liberally with rotten dung, woollen rags, ſhavings of horn, and other manures of an animal kind. Its great excellence, however, upon a ſandy ſoil, is by mechanically binding the looſe particles, and thereby preventing the liquid parts of the manure from eſcaping out of the reach of the radical fibres of the plants.

Upon clay the effect of lime is different; for by means of the gentle fermentation that it produces, the unſubdued ſoil is opened and divided; the manures laid on readily come into contact with every part of it; and the fibres of the plants have full liberty to ſpread themſelves.

It is generally ſaid that lime anſwers better upon ſand than clay. This obſervation will undoubtedly hold good as long as the farmer continues to lime his clay lands in a ſcanty manner. Let him treble the quantity, and he will then be convinced that lime is better for clay than ſand. It may be juſtly anſwered, that the profits will not admit of the expence. I agree. But then it muſt be underſtood that it is the application, and not the nature of the lime, that ſhould be called in queſtion. Clay, well limed, will fall in water, and ferment with acids. Its very nature is changed.

Under ſuch agreeable circumſtances, the air, rains, and dews are freely admitted, and the ſoil is enabled to retain the nouriſhment that each of them brings. In conſequence of a fermentation raiſed in the ſoil, the fixed air is ſet at liberty, which in a wonderful manner promotes vegetation.

It is the nature of lime to attract oils and diſſolve vegetable bodies. Upon theſe principles we may account for the wonderful effects of lime in the improvement of black moorland. Moor-earth conſiſts of diſſolved, and half-diſſolved, vegetable ſubſtances. It is full of oil.—Lime aſſimilates the one and diſſolves the other.

Such lands, not originally worth fourpence *per* acre, may be made, by paring, burning, and liming, to produce plentiful crops of turnips, which may be followed with oats, barley, or graſs-ſeeds, according to the inclination of the owner.——Theſe obſervations, however, are rather foreign to the argument of the preſent eſſay, to which I ſhall now return.

To the univerſal principle, oil, we muſt add another of great efficacy, though very little underſtood; I mean the nitrous acid of the air.

That the air does contain the rudiments of nitre, is demonſtrable from the manner of making ſalt-petre in the different parts of the world. The air contains no ſuch ſalt as perfect nitre; it is a factitious ſalt, and is made by the nitrous acid falling upon a proper matrix. The makers of nitre form that matrix of the rubbiſh of old houſes, fat earth, and any fixed alkaline ſalt. The univerſal acid, as it is called, is attracted by theſe materials, and forms true nitre, which is rendered pure by means of cryſtallization, and in that form it is brought to us. In very hot countries the natural earth forms a matrix for nitre, which makes the operation very ſhort.

It is obſerved that nitre is moſt plentifully formed in winter, when the wind is northerly: hence we may underſtand the true reaſon why land is fertiliſed by being laid up in high ridges during the winter months. The good effects of that operation are wholly attributed to the mechanical action of the froſt upon the ground. Light ſoils, as well as the tough ones, may be expoſed in high ridges, but with ſome limitation, in order to imitate the mud walls in Germany, which are found, by experience, to collect conſiderable quantities of nitre during the winter.

After ſaying ſo much in praiſe of nitre, it will be expected that I ſhould produce ſome proofs of its efficay, when uſed as a manure. I muſt confeſs that experiments do not give us any ſuch proofs. Perhaps too large a quantity has been uſed; or rather, it could not be reſtored to the earth with its particles ſo minutely divided, as when it remained united with the ſoil, by means of the chymiſtry of nature. I ſhall therefore conſider this nitrous acid, or, as philoſophers call it, the *acidum vagum*, in the light of a vivifying principle, with whoſe operation we are not yet fully acquainted.

I have already obſerved, that there ſubſiſts a ſtrong analogy between plants and animals. Oil and water ſeem to make up the nouriſhment of both. Earth enters very little into the compoſition of either. It is obſerved, that animals take in a great many earthly particles at the mouth, but they are ſoon diſcharged by urine and ſtool. Vegetables take in the ſmalleſt portion imaginable of earth; and the reaſon is, they have no way to diſcharge it.

It is highly probable, that the radical fibres of plants take up their nouriſhment from the earth, in the ſame manner that the lacteal veſſels abſorb the nutriment from the inteſtines; and as the oily and watery parts of our food are perfectly united into a milky liquor, by means of the ſpittle, pancreatic juice, and bile, before they enter the lacteals, we have all the reaſon imaginable to keep up the analogy, and ſuppoſe that the oleaginous and watery parts of the ſoil are alſo incorporated, previous to their being taken up by the abſorbing veſſels of the plant.

To form a perfect judgment of this, we muſt reflect that every ſoil, in a ſtate of nature, has in itſelf a quantity of abſorbent earth, ſufficient to incorporate its inherent oil and water; but when we load it with fat manures, it becomes eſſentially neceſſary to beſtow upon it, at the ſame time, ſomething to aſſimilate the parts. Lime, ſoap-aſhes, kelp, marl, and all the alkaline ſubſtances, perform that office.

In order to render this operation viſible to the ſenſes:—Diſſolve one drachm of Ruſſia pot-aſh in four ounces of water; then add one ſpoonful of oil. Shake the mixture, and it will inſtantly become an uniform maſs of a whitiſh colour, adapted to all the purpoſes of vegetation.

This eaſy and familiar experiment is a juſt repreſentation of what happens after the operation of Burn-baking, and conſequently may be conſidered as a confirmation of the hypotheſis advanced.——Let us attend to the proceſs.

The ſward being reduced to aſhes, a fixed alkaline ſalt is produced. The moiſture of the atmoſphere ſoon reduces that ſalt into a fluid ſtate, which, mixing with the ſoil, brings about an union of the oily and watery parts, in the manner demonſtrated by the experiment.

When the under ſtratum conſiſts of a rich vegetable mould, the effects of Burn-baking will be laſting. But when the ſoil happens to be thin and poor, the firſt crop frequently ſuffers before it arrives at maturity.

The farmer therefore, who is at the expence of paring and burning a thin ſoil, ſhould beſtow upon it a portion of rotten dung, or ſhambles manure, before the aſhes are ſpread, in order to ſupply the deficiency of oily particles.

In conſequence of this prudent management, the crop will be ſupported during its growth, and the land will be preſerved in health and vigour.

For ſuch weak lands, it is highly probable that the oil-compoſt deſcribed in the next eſſay, will be found the cheapeſt and moſt effectual manure.

Hitherto I have conſidered plants as nouriſhed by their roots. I ſhall now take a view of them as nouriſhed by their leaves. An attention to this part of the vegetable ſyſtem is eſſentially neceſſary to the rational farmer.

Vegetables that have a ſucculent leaf, ſuch as vetches, peaſe, beans, and buck-wheat, draw a great part of their nouriſhment from the air, and on that account impoveriſh the ſoil leſs than wheat, oats, barley, or rye, the leaves of which are of a firmer texture.

Rape and hemp are oil-bearing plants, and, conſequently, impoveriſhers of the ſoil; but the former leſs ſo than the latter, owing to the greater ſucculency of its leaf.

The leaves of all kinds of grain are ſucculent for a time; during which period the plants take little from the earth; but as ſoon as the ear begins to be formed, they loſe their ſoftneſs, and diminiſh in their attractive power.

The radical fibres are then more vigorouſly employed in extracting the oily particles of the earth, for the nouriſhment of the ſeed. Such, I apprehend, is the courſe of nature.

ESSAY II.

On a rich and cheap Compoſt, &c.

IN the laſt eſſay I endeavoured to ſhew that oil, made miſcible with water, conſtitutes the chief nouriſhment of vegetables. A greater number of proofs might have been produced in ſupport of that doctrine; but I flatter myſelf that thoſe already advanced will be thought ſufficient.

Having reaſon to believe that my theory was founded upon facts and experiments, I was deſirous of converting it to public utility. And as I apprehended that a compoſt might be diſcovered, upon the principles advanced, which would come cheap to the farmer, and be of eaſy carriage, I diligently employed myſelf in proſecuting the enquiry.

In the courſe of inveſtigation I took care to reaſon upon proper data, carefully avoiding every degree of partiality to my ſyſtem.——In philoſophy nothing is ſo deluſive as prejudice.

After making various trials, I at laſt diſcovered what I ſo ardently ſought after; but as I have not the vanity to think my experiments ſufficiently concluſive, I embrace this opportunity to requeſt the aſſiſtance of the practical farmer, in order that the merits of the invention may be fully determined.

Should my theory concerning the food of plants be thought erroneous, the compoſt will of courſe be diſregarded. But, on the contary, ſhould it be agreed to that oil, made miſcible with water, conſtitutes the chief nouriſhment of vegetables, then the invention will probably become a ſubject for future experiment.

Though theory may direct our enquiries, yet experience muſt at laſt determine our opinions, for which reaſon I propoſe to enlarge my experiments; and as I have no other view but the inveſtigation of truth, I ſhall lay them faithfully before the public, whether they prove ſucceſsful or not.

We know that a number of experiments, made by different perſons and in different places, are eſſentially neceſſary towards eſtabliſhing the truth of any received opinion in Agriculture. How much more neceſſary is it to requeſt the aſſiſtance of the practical farmer, in determining the merits of a new invention? for ſuch I eſteem the compoſt I here communicate.

Virgil, indeed, has recommended the lees of oil as a manure, and the ingenious Dr. Home has mentioned olive oil; but neither of them reflected upon the abſolute neceſſity of rendering the oil miſcible with water, by means of an alkaline ſalt.

I judge it unneceſſary to repeat what I have already advanced upon the food of plants. I ſhall therefore refer the reader to the firſt eſſay, as it contains the greateſt part of the reaſoning upon which the following compoſt is founded.

To make Oil-Compoſt.

	l.	s.	d.
Take North-American pot-aſh 12 lb.	0	4	0
Break the ſalt into ſmall pieces, and put it into a convenient veſſel with 4 gallons of water. Let the mixture ſtand forty-eight hours, then add coarſe train-oil, 14 gallons	0	14	0
£	0	18	0

In a few days the ſalt will be diſſolved, and the mixture, upon ſtirring, will become nearly uniform.

Take 14 buſhels of ſand, or 20 of dry mould. Upon theſe pour the above liquid ingredients. Turn this compoſition frequently over, and in ſix months it will be fit for uſe.

When the liquid ingredients are put to one or two hogſheads of water, a liquid compoſt will be formed, which muſt be uſed with a water-cart.

I apprehend that the above quantity will be found ſufficient for an acre; my trials, however, do not give me ſufficient authority to determine upon this point.

For the convenience of carriage, I have directed no more earth to be uſed than will effectually take up the liquid ingredients. But if the farmer chooſes to mix up the compoſt with the mould of his field, I would adviſe him to uſe a larger portion of earth, as he will thereby be enabled to diſtribute it with more regularity upon the ſurface. I have not yet had any extenſive trial of its efficacy upon meadow grounds; but I preſume that whatever will nouriſh corn, will alſo feed the roots of graſs. When uſed upon ſuch lands, it ſhould be put on during a rainy ſeaſon, and probably the liquid form will be found more eligible than the ſolid.

All kinds of cattle muſt be kept off the lands for ſome time, as they will bite the graſs too cloſe in queſt of the ſalt contained in the compoſt, which I have found to be the caſe in ſmall trials.

I ſhall here obſerve, that the oil-compoſt is only intended to ſupply the place of rape-duſt, ſoot, woollen rags, and other expenſive hand-dreſſings. It is in all reſpects inferior to rotten dung: where that can be obtained, every kind of manure muſt give place to it.

At the ſame time that dung affords nouriſhment, it opens the pores of the earth. Hand-dreſſings, on the contrary, give food to plants, but contribute little towards looſening the ſoil. This is an uſeful and practical diſtinction, and may be applied through all the variety of manures made uſe of by the farmer.

I preſume that the oil-compoſt reſembles the natural food of plants; but I ſubmit that, as well as every thing elſe, to experience, our unerring guide.

It may be objected, that it has not undergone the *putrid ferment*, to attenuate the oily particles. The uſe of rape-duſt, ſoot, horn ſhavings, and woollen rags take off that objection, and at the ſame time confirm the theory upon which the above compoſt is founded.

I do not take upon me to direct the experienced farmer in the manner of uſing this new compoſt. I would have every perſon apply it in the way moſt agreeable to himſelf. Many things will occur to the practical huſbandman, that no reaſoning of the philoſopher could foreſee. By attending to the different ways of uſing it, we may reap conſiderable advantages. Improvements may be collected even from the higheſt degree of miſmanagement.

Facts muſt ever be the foundation of our reaſoning. Without them the philoſopher is a kind of *Ignis fatuus.* Inſtead of unfolding nature he covers her with a cloud, and endeavours, as it were, to bring old Chaos back again into the world.

Should I preſume to inſtruct the farmer in the management of the compoſt, I would recommend it to be ſown immediately after the grain, and both harrowed in together.

The following experiment, though trifling in its own nature, gave me the firſt encouragement to proſecute the ſubject upon a larger ſcale.— I took four pots, N°. 1, 2, 3, 4.

N°. 1. contained 12 lb. of barren ſand, with 1 oz. of the ſand oil-compoſt.

N°. 2.—12 lb. of ſand, without any mixture.

N°. 3.—12 lb. of ſand, with ½ oz. of ſlaked lime.

N°. 4.—12 lb. of ſand, with 4 oz. of the ſand oil-compoſt.

In the month of March, I put ſix grains of wheat into each pot, and during the ſummer I occaſionally watered the plants with filtered water. All the time that the plants were conſuming the farina, I could obſerve but little difference in their appearance. But after one month's growth I remarked that N°. 1. was the beſt. N°. 2. the next. N°. 3. the next. N°. 4. much the worſt.

In Auguſt, I made the following obſervations.

N°. 1. had five ſmall ears, which contained a few poor grains.

N°. 2. had three ſmall ears, which ſcarce deſerved the name of ears, containing a few grains, much inferior in goodneſs to the former.

N°. 3. had no ears. Only I obſerved two very ſmall ones within their reſpective ſheaths, which, for want of vegetable ſtrength, never made their appearance.

N°. 4. had no ears; the ſtalks appearing ſtunted in their growth.

I removed the plants from their pots, and took a view of the roots of each.

N°. 1. The roots tolerably large, and well ſpread.

N°. 2. The roots not ſo large.

N°. 3. The roots very ſhort and ſmall.

N°. 4. The roots much the ſhorteſt, with the appearance of being ricketty.

Upon this experiment I remark:

1. That the oil-compoſt may be conſidered as a vegetable food: but that, when uſed too

liberally, the alkaline ſalt will burn up the roots of the plant, and hinder vegetation. For which reaſon I would recommend the compoſt to be expoſed to the influence of the air, for ſome months, before it is laid on.

2. That lime contains no vegetable food, and is, in its own nature, an enemy to vegetation. It is, however, of excellent uſe in aſſiſting vegetation, in the manner deſcribed in the firſt eſſay.

My experiments teach me, that all kinds of ſoils may be benefited by this manure. The limeſtone, gravelly, ſandy, and chalky ſoils ſeem to require it moſt. The rich loams and good clays have nouriſhment within themſelves, and ſtand more in need of the plow than the dunghill.

It is obſerved by farmers, that rape-duſt ſeldom ſucceeds with ſpring-corn, unleſs plentiful rains fall within a few weeks after ſowing. I have more than once made the ſame obſervation upon the oil-compoſt, which induces me to recommend it for winter crops only. From the unctuouſneſs of its nature, it is more than probable that it ſhould lie expoſed for a long time to the influence of the weather, which benefit it is deprived of when uſed for barley, and ſuch crops as are ſown late in the ſpring. I am confirmed in this idea, from repeated experiments made with the compoſt upon turnips, which generally proved unſucceſsful. But at the ſame time I invariably found that thoſe parts of the field on which the compoſt had been ſpread, produced the beſt crops of grain the following year. From this ſlow manner of giving its virtues, it ſeems to be an improper dreſſing for all plants that have a quick vegetation.

Agreeable to the theory advanced in the firſt eſſay, I preſume that all lands, which have been exhauſted by frequent crops, are robbed of their oily particles, and conſequently have become barren. The oil-compoſt, as it plentifully reſtores particles ſimilar to thoſe that are carried off, has a fair appearance of proving an excellent reſtorative. To lands under ſuch circumſtances, lime is the worſt manure that can be applied.

This laſt obſervation naturally leads me to wiſh for a general hiſtory of manures, upon ſound and rational principles. I cannot help regarding that neceſſary part of huſbandry as a ſubject but imperfectly underſtood. Whoever ſucceeds in that difficult taſk, will prove himſelf a real friend to mankind. Without it, Agriculture muſt remain a vague and uncertain ſtudy.

ESSAY III.

On Vegetation, and the Analogy between Plants and Animals.

VEgetables are placed in a middle degree between animals and minerals. They are ſuperior to minerals, in having organized parts; but inferior to animals, in being deſtitute of ſenſation.

As they are fixed to a place, they have few offices to perform. An increaſe of body and maturation of their ſeed, ſeems all that is required of them. For theſe purpoſes providence has wiſely beſtowed upon them organs of a wonderful mechaniſm. The anatomical inveſtigation of theſe organs, is the only rational method of arriving at any certainty concerning the laws of the vegetable œconomy. Upon this ſubject Dr. Hales judiciouſly obſerves, "that as the growth and preſervation of vege-"table life is promoted and maintained, as in "animals, by the very plentiful and regular "motion of their fluids, which are the vehicles "ordained by nature to carry nutriment to "every part, it is therefore reaſonable to hope "that in them alſo, by the ſame method of "enquiry, conſiderable diſcoveries may in time "be made, there being, in many reſpects, a "great analogy between plants and animals."

The ſeed of a plant, after it has dropt from the ovarium, may be conſidered as an impregnated ovum, within which the embryo plant is ſecurely lodged. In a few days after it has been committed to the earth, we may diſcern the rudiments of the future plant. Every part appears to exiſt in miniature. The nutritive juices of the ſoil inſinuate themſelves between the original particles of the plant, and bring about an extenſion of its parts. This is what is called the growth of the vegetable body.

With regard to this increaſe by addition and extenſion, there ſeems to be a great analogy between the animal and vegetable kingdoms. In a former eſſay I endeavoured to prove, that oily particles conſtitute the chief nouriſhment of plants and animals; and as I apprehend that much depends upon a proper inveſtigation of the ſubject, I ſhall occaſionally introduce ſome other proofs in ſupport of my opinion.

Every one knows that animals, inſtead of being ſtrengthened, are enfeebled by a ſupply of improper nouriſhment. It is the ſame thing with regard to vegetables; but with this difference, that animals refuſe whatever is improper, while vegetables, from their paſſive nature, muſt be content with what we give them.

When a farmer once becomes acquainted with the nature of the food of plants, he will find himſelf rationally inſtructed in the manner of compounding dunghills, and the application of the various manures made uſe of in huſbandry. At preſent no part of rural œconomy is ſo imperfectly underſtood.——But to return.

The impregnated ovum of every animal, after it has paſſed down the Fallopian tube, and fixed itſelf to the bottom of the uterus, is found to contain the tender embryo within two membranes called Chorion and Amnion. In this ſituation the embryo could not long ſubſiſt without a ſupply of nouriſhment. Nature has therefore beſtowed upon it a placenta and umbilical chord, through which the blood and juices of the mother are tranſmitted, for its preſervation and increaſe.

Seeds are diſpoſed by providence, nearly in the ſame manner. They have two coverings, anſwering to the Chorion and Amnion, and two lobes which perform the office of the placenta. Theſe lobes conſtitute the body of the ſeed, and, in the farinaceous kinds, they are the flour of the grain. Innumerable ſmall veſſels run through the ſubſtance of the lobes, which, uniting as they approach the ſeminal plant, form a ſmall chord to be inſerted into the body of the germ. Through it the nutriment ſupplied by the placenta, or lobes, is conveyed for the preſervation and increaſe of the embryo plant.

In order that I may be clearly underſtood, it will be neceſſary to obſerve, that the lobes of farinaceous grains are fixed in the earth. They are therefore improperly termed ſeminal leaves, being rather the placenta, or cotyledons of the plant. On the contrary, vegetables that have an oily ſeed, as rape, hemp, line, and turnip,

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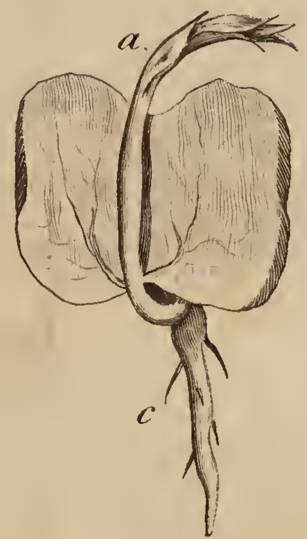
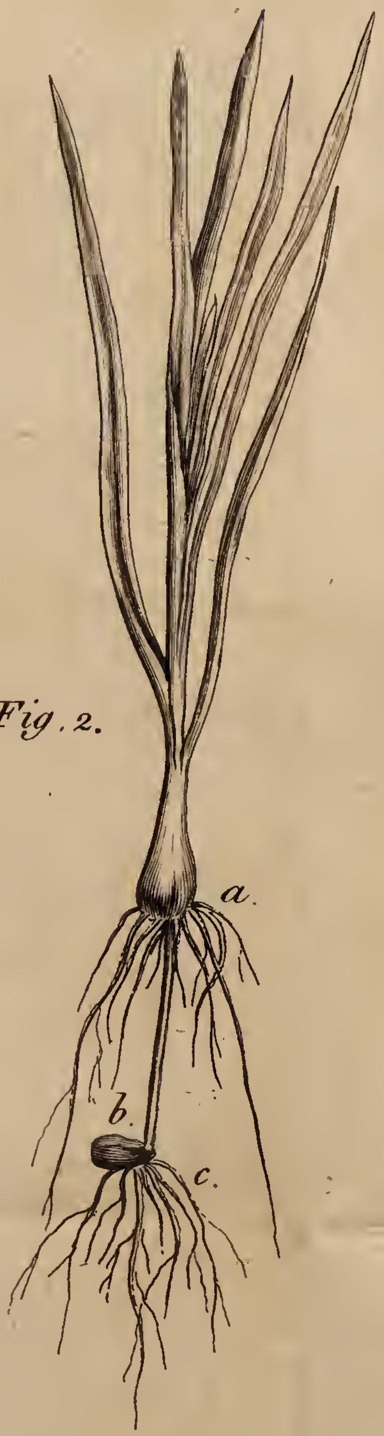


Fig. 1.



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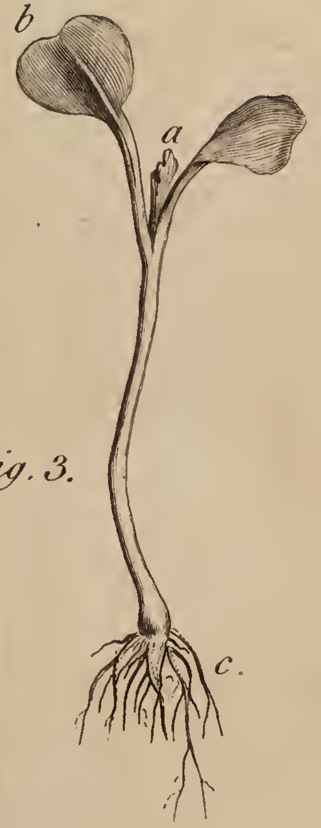

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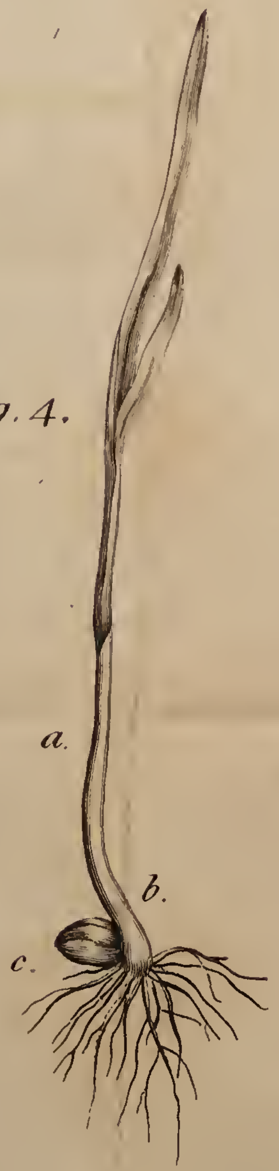

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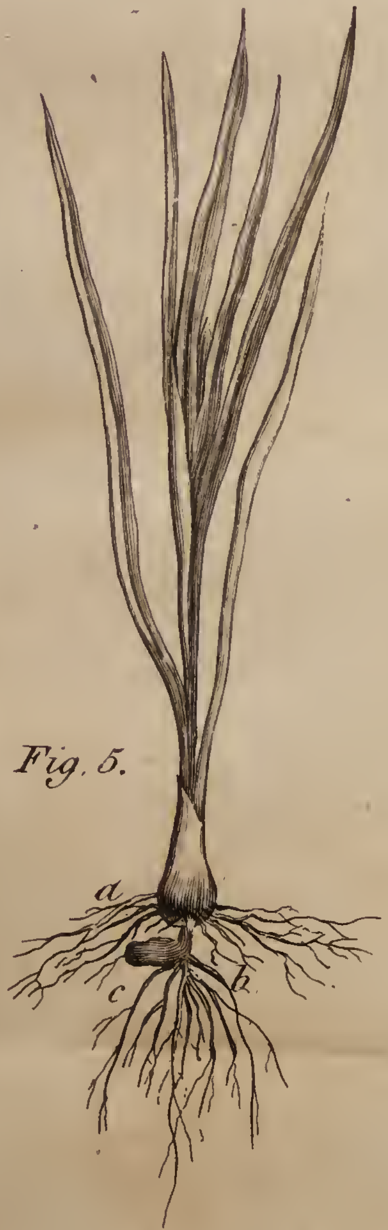

Fig. 5.

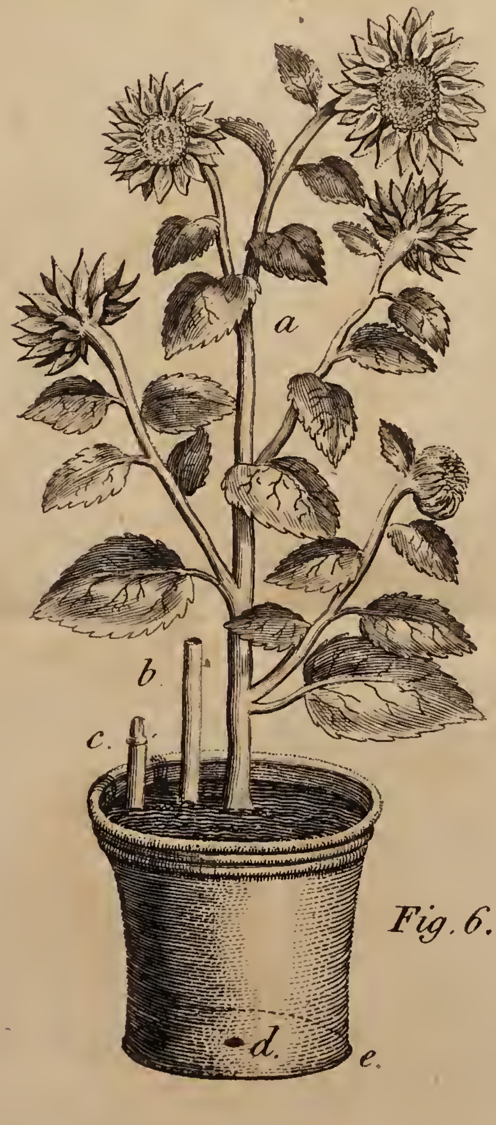

Fig. 6.

carry their lobes upward, and ſpread them upon the ſurface, in the form of broad leaves. Theſe, though they perform the office of a placenta, are properly ſeminal leaves;—and to this diſtinction I ſhall adhere.

Plate 1. Fig. 1. repreſents the body, or placenta, of a bean, with its germ, radicle, umbilical chord, and ramifications.— *a*. The germ. *b*. The body, or placenta, with the umbilical chord and ramifications.— *c*. The radicle.

Fig. 3. repreſents the placenta, or ſeed-leaves, of a turnip, with its radicle and germ.— *a*. The germ.— *b*. The placenta, or ſeed-leaves. —— *c*. The radicle.

Fig. 4. repreſents the germ of a grain of wheat, with its root and capſule, containing the milky juice for the nouriſhment of the tender plant.— *a*. The origin of the crown.—— *b*. The pipe of communication between the firſt roots and the crown.— *c*. The grain with its firſt roots.

To illuſtrate the ſubject of vegetation, let us take a view of what happens to a bean, after it has been committed to the earth.

In few days, ſooner or later, according to the temperature of the weather and diſpoſition of the ſoil, the external coverings open at one end, and diſcloſe to the naked eye part of the placenta, or body of the grain. This ſubſtance conſiſts of two lobes, between which the ſeminal plant is ſecurely lodged. Soon after the opening of the membranes, a ſharp-pointed body appears. This is the root. By a kind of principle, which ſeems to carry with it ſome appearance of inſtinct, it ſeeks a paſſage downwards, and fixes itſelf into the ſoil. At this period the root is a ſmooth and poliſhed body, and perhaps has but little power to abſorb any thing from the earth, for the nutriment of the germ.

The two lobes now begin to ſeparate, and the germ, with its leaves, may plainly be diſcovered. As the germ increaſes in ſize, the lobes are further ſeparated, and the tender leaves being cloſely joined, puſh themſelves forward in the form of a wedge.

Theſe leaves take a contrary direction to the root. Influenced by the ſame miraculous inſtinct, if I may be allowed the expreſſion, they ſeek a paſſage upward, which having obtained, they lay aſide their wedge-like form, and ſpread themſelves in a horizontal direction, as being the beſt adapted for receiving the rains and dews.

The radicle, every hour increaſing in ſize and vigour, puſhes itſelf deeper into the earth, from which it now draws ſome nutritive particles. At the ſame time the leaves of the germ, being of a ſucculent nature, aſſiſt the plant, by attracting from the atmoſphere ſuch particles as their tender veſſels are fit to convey. Theſe particles, however, are of a watery kind, and have not, in their own nature, a ſufficiency of nutriment for the increaſing plant.

Vegetables and animals, during their tender ſtates, require a large ſhare of balmy nouriſhment. As ſoon as an animal is brought into life, the milk of its mother is ſupplied in a liberal ſtream, while the tender germ ſeems only to have the crude and watery juices of the earth for its ſupport. In that, however, we are deceived. The author of nature, with equal eye, watches over the infancy of all his works. The animal enjoys the milky humour of its parent. The vegetable lives upon a ſimilar fluid, though differently ſupplied. For its uſe the farinaceous lobes are melted down into a milky juice, which, as long as it laſts, is conveyed to the tender plant by means of innumerable ſmall veſſels, which are ſpread through the ſubſtance of the lobes. Theſe veſſels, uniting into one common trunk, enter the body of the germ, and perform the office of an umbilical chord. Without this ſupply of balmy liquor, the plant muſt inevitably have periſhed, its root being then too ſmall to abſorb a ſufficiency of food, and its body too weak to aſſimilate it into nouriſhment. See Plate 1. Fig. 1.

Turnips, and all the tribe of Braſſicas, in oppoſition to the leguminous and farinaceous plants, ſpread their ſeminal leaves upon the ſurface. Theſe leaves contain all the oil of the ſeed, which, when diluted by the moiſture of the atmoſphere, forms an emulſion of the moſt nouriſhing quality. How ſimilar is this juice to the milk of animals! On account of its ſweetneſs, the ſeminal leaves are greedily devoured by the fly.

This demonſtrably proves that oil conſtitutes the nouriſhment of plants in their tender ſtate; and, by a fair inference, we may ſuppoſe that it alſo nouriſhes them as they advance in growth.

A grain of wheat, as ſoon as the germ has made its appearance, ſhews the milky liquor to the naked eye; but the umbilical chord, with its ramifications, can only be diſcovered by the aſſiſtance of the niceſt glaſſes. As the plant increaſes in ſize the balmy juice diminiſhes, till at laſt it is quite exhauſted. The umbilical chord then dries up, and the external covering of the grain appears connected to the root in the form of a ſhrivelled bag. See Plate 1. Fig. 2. *c*.

Here is no mortality. From the moment that the ſeed is lodged in its parent earth, the vegetative ſoul begins its operations, and, in one continued miracle, proves the wiſdom and bounty of an almighty providence.

It is worthy of obſervation, that farinaceous vegetables and oviparous animals are nouriſhed, in their tender ſtates, nearly in the ſame manner.

We have already ſeen that the embryo plant is ſupported by the farina melted down into a milky liquor, and conveyed into its body by means of an umbilical chord, at a time when the radicle was unable to ſupply a ſufficiency of nutriment.

An oviparous animal, from the time that it is brought into light, ſeems to receive all its nouriſhment from without. This, however, is only an appearance. The yolk of the egg, remaining intire during incubation, is received into the body of the animal, and, in a manner ſimilar to the paſſage of the milky juice of the vegetable, is ſlowly conveyed into the veſſels of the tender chick. Thus a ſweet nouriſhment is prepared at a time when neither the induſtry of the animal, nor the attention of its mother, could have procured a ſufficient ſupply.

How beautiful are the general laws of providence! The more we explore them, the more we have cauſe for wonder and aſtoniſhment. Every thing is wiſely diſpoſed; nothing is fortuitous: all is order, regularity, and wiſdom.

ESSAY IV.

On Steeps.

THE ſteeping of ſeeds in prolific liquors is not of modern invention. The Romans, who were good huſbandmen, have left us ſeveral receipts for the ſteeping of grain, in order to increaſe the powers of vegetation. In England, France, Italy, and in all countries where Agriculture has been attended to, we ſee a variety of liquors recommended for the ſame purpoſe.——Good nouriſhment has ever been obſerved to add ſtrength and vigour to all vegetables. Hence it was natural to ſuppoſe that, by filling the veſſels of the grain with nouriſhing liquors, the germ, with its roots, would be invigorated. How far this reaſoning is founded upon juſt principles, remains to be examined.

For my part, I am not an advocate for ſteeps. All my experiments demonſtrate that they have no inherent virtue. I have more than once ſown the ſame ſeed, ſteeped and unſteeped, and though all other circumſtances were minutely alike, yet I never could obſerve the leaſt difference in the growth of the crop. I confeſs that when the light ſeeds are ſkimmed off, as in the operation of brining, the crop will be improved, and diſeaſes prevented: but theſe advantages proceed from the goodneſs of the grain ſown, and not from any prolific virtue of the ſteep.

I am happy in not being ſingular in my objection to ſteeps. Many rational farmers have been induced to quit their prejudices, and are now convinced, from their own trials, that there is no dependence upon prolific liquors, though ever ſo well recommended.—Some people have been hardy enough to perſuade themſelves, that the tillering of wheat may be ſo much increaſed by invigorating the grain, that only one half of the ſeed will be required.

Duhamel, one of the moſt accurate of the experimental huſbandmen, and a moſt excellent philoſopher, ſpeaks, in the ſtrongeſt terms, againſt the practice of ſteeping, ſo far as it ſuppoſes an impregnation of vegetative particles. I ſhall not here repeat his experiments. I ſhall only obſerve, that they are ſuch as any farmer may make. They are plain and concluſive.

Good ſeed, when ſown upon land in excellent tilth, will always produce a plentiful crop. The beſt of grain impregnated to the full with the moſt approved ſteep, and ſown upon land indifferently prepared, will for ever balk the hopes of the farmer.

I do not preſume to condemn the practice in poſitive terms, becauſe my experiments are againſt it. Other experiments may be oppoſed to mine. I ſhall therefore reſt the whole upon a deſcription of what happens to the grain after it has been committed to the earth, and hope that I ſhall be able to explain myſelf with ſufficient perſpicuity.——The ſubject is curious, and the diſcuſſion of it not very difficult.

A grain of wheat contains, within two capſules, a conſiderable ſhare of flour, which, when melted down into a liquor by the watery juices of the earth, conſtitutes the nouriſhment of the tender plant, until its roots are grown ſufficiently large to abſorb their own food. Here is evidently a ſtorehouſe of nutriment. And from that idea it is plain that the plumpeſt grains are the moſt eligible for ſeed.

Some have imagined that poor grains may be ſo impregnated, as to make them equal in vegetative force to the largeſt. I have more than once made the experiment, and am convinced that plump ſeeds, of the ſame heap, are ſuperior in goodneſs to the ſmall ones, though ever ſo carefully macerated. The farina being the food of the embryo plant, it follows that the vegetative powers will be increaſed in proportion to its quantity.

I have ſprouted all kinds of grain in a variety of ſteeps, and can aſſure the farmer, that the radicle and germ never appeared ſo vigorous and healthy, as when ſprouted by elementary water: an argument that the ſeed requires no aſſiſtance. The ſame ſteep, when applied in quantity to the ſoil, will undoubtedly invigorate the roots, and nouriſh the plant; but in that caſe it operates in common with other manures, and loſes the idea of a ſteep.

As nitre, ſea-ſalt, and lime, are generally added to the ſteeps, I have conſtantly obſerved that their application rendered the radicle and germ yellow and ſickly: a plain proof that they were unnaturally uſed at that ſeaſon. Did the farina need any additional particles, it might be ſuppoſed, that broth made of the fleſh of animals would be the moſt agreeable. To be ſatisfied of that, I ſprouted ſome grains in beef broth, and an equal number in ſimple water. The reſult was, that the radicle and germ produced by the broth, were weaker and leſs healthy than the others ſprouted by the pure element. They were afterwards ſown, but I could perceive no apparent difference in the crop.

From theſe, and many other reaſons, I am induced to think that all invigorating ſteeps are only additional troubles and expence to the farmer. Correct experiments do not ſeem to prove their efficacy.

It is cuſtomary for the farmer to brine his ſeed-wheat and afterwards to lime it, with a view to prevent the ſmut. Some late improvers ridicule this piece of practice, but without reaſon. The brine and lime, by a kind of corroſion, acts upon ſuch ſeeds as are infected with ſmut. Laſt year I ſaw a land of wheat ſown with ſmutty grain, and four fifths of the crop came up infected, while the other lands in the ſame field were free from the diſeaſe. And here I beg leave to obſerve, that I confine my idea of ſteeps to the ſuppoſed power of giving to ſeeds a vegetative force by means of certain *prolific* liquors which are thought to invigorate the germ, by mixing with the farinaceous part of the ſeed.

To ſum up all. I ſhall venture to ſay, that plump ſeed clear of weeds, and land well prepared to receive it, will ſeldom diſappoint the expectations of the farmer: and upon theſe he ſhould rely for the goodneſs of his crop.

ESSAY V.

On the Roots of Wheat.

IT is not ſufficient for the farmer to be acquainted with the nature of the different ſoils. He ſhould alſo know the ſhape of the roots of ſuch plants as are uſed in field-huſbandry. The ſoil and roots are ſo intimately connected, that the knowledge of both becomes eſſential.

I have ſelected the roots of wheat for the ſubject of the preſent eſſay. That grain, being the moſt valuable, demands our greateſt attention.

Wheat has two ſets of roots. The firſt comes immediately from the grain; the other ſhoots from the crown ſome time after. I ſhall diſtinguiſh them by *ſeminal* and *coronal* roots.

Plants, according to their ſpecies, obſerve a regular uniformity in the manner of ſpreading their roots; for which reaſon the ſame grain cannot be continued long upon the ſame ſoil. It is not that each takes from the earth ſuch particles as are congenial. The food of all plants is the ſame; only ſome require more, ſome leſs. Some take it near the ſurface, others ſeek it deeper.——This opens to our view a noble field of inſtruction. A careful inſpection of a healthy root will at once demonſtrate the bias of nature. An examination of the ſoil will ſhew how far they will coincide. This is the rational baſis of the change of ſpecies.

Wheat being ſubject to the ſeverity of winter, its roots are wonderfully diſpoſed to withſtand the inclemency of the ſeaſon. A view of their ſhape will direct us in the manner of ſowing that grain to the moſt advantage; and at the ſame time enable us to account for ſome of the phænomena obſervable in the growth of it.

I have obſerved that wheat has a double root. The firſt, or *ſeminal* root, is puſhed out at the ſame time with the germ, which, together with the farina, nouriſhes the plant until it has formed its crown. Plate 1. Fig. 4.—*a.* The origin of the crown.—*b.* The pipe of communication. *c.* The grain with its *ſeminal* root.

When the crown has become ſufficiently large, it detaches a number of ſtrong fibres, which puſh themſelves obliquely downwards. Theſe are the *coronal* roots. A ſmall pipe preſerves the communication between them and the *ſeminal* roots. It makes an eſſential part of the plant, and is obſerved to be longer or ſhorter, according to the depth that the ſeed has been buried. It is remarkable, however, that the crown is always formed juſt within the ſurface. Its place is the ſame, whether the grain has been ſown deep or ſuperficial. I believe I do not err when I call this *vegetable inſtinct.* As the increaſe and fructification of the plant depends upon the vigorous abſorption of the *coronal* roots, it is no wonder that they ſhould fix themſelves ſo near the ſurface, where the ſoil is always the richeſt.

In the northern counties wheat is generally ſown late. When the froſt comes the *coronal* roots, being young, are frequently chilled. This inconvenience, however, may eaſily be prevented by ſowing more early, and burying the ſeed deeper. The *ſeminal* roots being out of the reach of the froſt, will then be enabled to ſend up nouriſhment to the crown, by means of the pipe of communication.

Plate 1. Fig. 2. repreſents a plant of wheat ſown at a proper depth.— *a.* The crown with its roots.— *b.* The pipe of communication.— *c.* The *ſeminal* roots, with the capſule of the grain.

Plate 2. Fig. 5. ſhews a plant of wheat ſown ſuperficial.— *a.* The crown and roots.— *b.* The pipe of communication.— *c.* The *ſeminal* roots, and capſule of the grain.

Hence it is obvious that wheat, ſown ſuperficially, muſt be expoſed to the ſeverity of the froſt from the ſhortneſs of the pipe of communication. The plant, in that ſituation, has no benefit from its double root. On the contrary, when the grain has been properly covered, the *ſeminal* and *coronal* roots are kept at a reaſonable diſtance.——The crown, being well nouriſhed during the winter, ſends up numerous ſtalks in the ſpring.——On the tillering of the corn, the goodneſs of the crop principally depends. A field of wheat, ſown in equi-diſtant rows by the drill-plow, always makes a better appearance than one ſown by the harrows. In the one, the pipe of communication is long; and in the other, ſhort.

From theſe anatomical facts many practical advantages may be reaped. I ſhall not here relate them. They will readily occur to the diſcerning huſbandman.

ESSAY VI.

On Vegetation and the Motion of the Sap.

ANimal bodies, from the nature of their ſtructure, are liable to diſeaſes. Vegetables, being leſs complicated, have fewer maladies. The laws of the animal œconomy are diſcovered by anatomical inſpection. The vegetable œconomy has the ſame foundation.

Malpighi and Grew, unknown to each other, undertook the anatomy of plants nearly about the ſame time. The engravings that they have left us are laſting monuments of their induſtry and attention. Many things, however, have been found out ſince their days. Many things remain yet to be diſcovered.

The general and obvious parts of a plant are five. The root, the ſtem, the branches, the leaves, the flower. The component parts of theſe diviſions are ſimple in compariſon to the animal body. The offices of a vegetable being only increaſe and fructification, there was no neceſſity for a complicated ſtructure.

A good microſcope diſcovers the conſtituent parts of a plant to be, 1. A very thin outer rind. 2. An inner rind, much thicker than the former. 3. A blea, of a ſpungy texture. 4. A vaſcular ſeries. 5. A fleſhy ſubſtance, which anſwers to the wood of a tree, or ſhrub. 6. Pyramidal veſſels contained within the fleſh. And, 7. A pith.

Whatever part of the plant we examine, we obſerve theſe, and no more. The root, its aſcending ſtalk, and deſcending fibre, are one, and not three ſubſtances. This reduces the entire vegetable to one body, and what appears in the flower to be many parts, are only the extremities of the ſeven above-mentioned. The cup terminates the outer bark. The inner rind ends in the outer petals. The blea forms the inner petals. The vaſcular ſeries ends in the nectaria. The fleſh makes the filaments. The pyramidal veſſels form the receptacle. The pith furniſhes the ſeeds and their capſules.

Words not being able to convey an adequate idea of theſe parts, I muſt beg leave to refer the reader to the excellent engravings of Dr. Hill, as publiſhed in his Vegetable Syſtem.

As I apprehend that his reſearches into the vegetable creation are more minute than thoſe of his predeceſſors, I have followed him in the enumeration of the conſtituent parts of a plant. He has juſtly recommended the black helebore as the propereſt ſubject for diſſection. It is a perennial plant of a firm texture, and not too complex, conſiſting only of a root, radical leaves, and a flower ſtem.

A careful maceration of the parts, a good microſcope, and a moſt delicate touch, are eſſentially neceſſary towards inveſtigating the ſtructure of vegetable bodies.

Trees, ſhrubs, and herbs are organized in the ſame manner; but the colour and thickneſs of their component parts are different, according to their reſpective natures.

The outer bark is the firſt thing that preſents itſelf to our view. It has the appearance of a fine film full of irregular meſhes, though in reality it conſiſts of two membranes, with a ſeries of veſſels between them. Theſe take their courſe upwards, and as they advance towards the cup of the flower inoſculate with the ſmall veſſels of the inner bark, into which they pour part of the juices they have received from the earth and the atmoſphere. The fine meſhes ſerve the purpoſes of inhalent or exhalent pores, according to the circumſtances of the weather.

The inner bark is much thicker than the outer. It is made up of ſeveral flakes laid evenly upon one another, each of which conſiſts of two membranes incloſing a ſeries of veſſels. Theſe communicate freely through the whole ſubſtance of the rind, and as they inoſculate with the veſſels of the outer bark, ſo they alſo communicate with thoſe of the blea.

The blea lies immediately under the inner bark. It is one compleat and ſingle ſubſtance, uniform in its ſtructure. It is of a conſiderable thickneſs, and is made up of beds of hexagonal cells. In the angles formed by theſe cells, we obſerve the veſſels of the blea. They pour their contents into the cells, which appear to be reſervoirs for the water imbibed by the plant.

Underneath the blea, lies the fourth ſubſtance called the Vaſcular Series. Its ſtructure is extremely ſimple, being a ſingle courſe of greeniſh veſſels lodged between two membranes. It terminates in the nectaria. At a certain ſeaſon of the year, the juices of the vaſcular ſeries are very mucilaginous. They are particularly ſo in the holly, and ſeem to be more elaborated than thoſe of the blea. Its veſſels have a free communication with the wood and blea.

The favourers of a circulation aſſert that, through theſe veſſels, the returning ſap deſcends; but by the moſt accurate experiments of Dr. Hales, it appears that the vegetable juices do riſe and fall in the ſame ſeries of veſſels, and conſequently have no circulation.

The wood, or fleſhy part of a plant, comes next to be examined. In this the life of the vegetable ſeems to be placed. It is univerſal in the plant, and is made up of ſtrong fibres. From it all the other parts are produced. It ſhoots a pith inward, and a rind, blea, and vaſcular ſeries outward. The filaments in the flower, which are eſſential parts in the production of new plants, are continuations of it. And as the ſeed-veſſels are portions of the pith, ſo are the petals and nectaria continuations of the rind, blea, and vaſcular ſeries; all which the plant ſhoots outward. Through every part of the wood, or fleſh, there are veſſels that carry a juice highly elaborated, the greateſt part of which has undergone the concoction of the rinds, blea, and vaſcular ſeries. The woody fibres conſtitute an order of veſſels, which are named Tracheæ. Theſe are filled with elaſtic air, and may be diſcovered, by the eye, in the wood of all trees. The Tracheæ make up an arterial ſyſtem, and ſupply the place of the heart in animals. Being filled with air, they become ſubject to the alternacies of heat and cold. Their uſe ſhall be explained hereafter.

The pyramidal veſſels are ſpread through all the ſubſtance of the fleſh, and, as they advance upwards, their ramifications inoſculate, ſo as to prevent any poſſible obſtruction of the ſap. Their juices, as I have obſerved, are highly elaborated, having paſſed through all the orders of ſap-veſſels. It will here be neceſſary to remark, that the ſides of theſe veſſels are conſtantly in contact with the Tracheæ; ſo that, from the nature of their ſituation, they muſt, at all times, be ſubject to the viciſſitudes of the weather. The pyramidal veſſels communicate with the pith, which remains to be deſcribed.

The pith is to be found in all trees, ſhrubs, and plants. It occupies the centre, but is not always regularly continued. When examined by a microſcope, it has the appearance of a number of veſicles, and is of an uniform ſtructure. It does not appear to be abſolutely neceſſary to vegetation, as we often obſerve elms, and other trees, to live and thrive without it. In trees it is found in the branches, being obliterated in the trunk. The veſſels of the fleſh communicate with it. From them it receives a fluid; and probably it is the receptacle of ſome part of the ſap. In extreme dry weather ſuch a ſtore may be neceſſary.

Tranſverſe ſections of the ribs of leaves diſcover it. When minutely traced, it is found to run up to the ovarium, where it forms the ſeeds and their capſules.

From this ſurvey of the anatomy of a plant, it is evident that there is a correſpondence between all its parts. By means of a variety of ſtrainers, different juices are prepared from the ſame maſs. Matter, conſidered as matter, has no ſhare in the qualities of bodies. It is from the arrangement of it that we have ſo many different ſubſtances in nature. We may eat the earth, and we may drink the water that moiſtens it, and yet, from the modification of its parts, it is capable of producing both bread and poiſon.

We reaſon improperly, when we ſay that every plant takes from the earth ſuch particles as are natural to it. A lemon, ingrafted upon an orange ſtock, is capable of changing the ſap of the orange into its own nature, by a different arrangement of the nutritive juices. A maſs of innocent earth can give life and vigour to the bitter aloe, and to the ſweet cane; to the cool houſe-leek, and to the fiery muſtard; to the nouriſhing grains, and to the deadly night-ſhade.

The fibres of a root are ſuppoſed to be ſimple capillary tubes: but, upon a minute inſpection, we diſcover them to conſiſt of the ſeven component parts of the plant. At their extremities we obſerve a ſpungy kind of excreſence pierced with innumerable ſmall holes. Through theſe the nutritive juices of the earth are abſorbed. When a plant has been pulled up, it will be retarded in its growth, until nature has renewed that ſpungy nipple.

The bark and leaves of a plant imbibe, at proper ſeaſons, the moiſture of the atmoſphere. At other times they perſpire the ſuperfluous nouriſhment. This opens to our view an extenſive proſpect of the vegetable œconomy.

We have already ſeen that all the parts of a plant are the ſame. They only differ in ſhape. The roots are formed ſharp and pointed, to make their paſſage eaſier through the earth. The leaves are made broad, to catch the moiſture of the air with more readineſs. When the root of a tree happens to be elevated, inſtead of being retained within the earth, it aſſumes the appearance of a perfect plant, with leaves and branches. Experiments ſhew us that a young tree may have its branches placed in the earth, and its roots elevated in the air; and in that inverted ſtate it will continue to live and grow.

The air contains, eſpecially during the ſummer months, all the principles of vegetation. Oil for the perfect food, water to dilute it, and ſalts to aſſimilate it. Theſe are greedily abſorbed by the veſſels of the leaves and bark, and conveyed to the innermoſt parts of the plant for its growth and fructification. When the air happens to be cold and moiſt, this abſorption takes place. When it is hot and dry, the ſame veſſels throw off the ſuperfluous moiſture by perſpiration. In animals, the kidneys and pores of the ſkin carry off the ſuperfluity. The vegetable not having kidneys, perſpires more than the animal.

Dr. Hales has demonſtrated that this perſpiration is conſiderable. I ſhall here tranſcribe his ſtatical experiments upon the ſun-flower, for the benefit of thoſe who may not have an opportunity of examining the original.

" July 3, 1724. In order to find out the " quantity imbided and perſpired by the ſun-" flower, I took a garden-pot (Plate 1. Fig. 6.) " with a large ſun-flower, *a*, 3 feet + ½ high, " which was purpoſely planted in it when " young: it was of the large annual kind.

" I covered the pot with a plate of thin mill-" ed lead, and cemented all the joints faſt, ſo " as no vapour could paſs, but only air, thro' " a ſmall glaſs tube, *b*, nine inches long, which " was fixed purpoſely near the ſtem of the plant, " to make a free communication with the out-" ward air, and that under the leaden plate.

" I cemented alſo another ſhort glaſs tube, *c*, " into the plate, two inches long and one inch " in diameter. Through this tube I watered " the plant, and then ſtopped up alſo the " holes, *d*, *e*, at the bottom of the pot with " corks.

“ I weighed this plant and pot, morning and “ evening, for fifteen ſeveral days, from July 3 “ to Auguſt 8, after which I cut off the plant “ cloſe to the leaden plate, and then covered “ the ſtump well with cement, and upon weigh- “ ing found there perſpired through the un- “ glazed porous pot two ounces every twelve “ hours day, which being allowed in the daily “ weighing of the plant and pot, I found the “ greateſt perſpiration of twelve hours, in a “ very warm dry day, to be one pound fourteen “ ounces; the middle rate of perſpiration, one “ pound four ounces. The perſpiration of a dry “ warm night, without any ſenſible dew, was “ about three ounces; but when any ſenſible, “ though ſmall dew, then the perſpiration was “ nothing; and when a large dew, or ſome little “ rain in the night, the plant and pot was in- “ creaſed in weight two or three ounces.

“ N. B. I uſed avoirdupois weights.

“ I cut off all the leaves of this plant, and “ laid them in five ſeveral parcels, according “ to their ſeveral ſizes, and then meaſured the “ ſurface of a leaf of each parcel, by laying “ over it a large lattice made with threads, in “ which the little ſquares were a quarter of an “ inch each; by numbering of which I had the “ ſurface of the leaves in ſquare inches, which,

“ multiplied by the number of the leaves in the
“ correſponding parcels, gave me the area of
“ all the leaves; by which means I found the
“ ſurface of the whole plant, above ground, to
“ be equal to 5616 ſquare inches, or 39 ſquare
“ feet.

“ I dug up another ſun-flower, nearly of the
“ ſame ſize, which had eight main roots, reaching
“ fifteen inches deep and ſideways from the
“ ſtem: it had beſides a very thick buſh of
“ lateral roots, from the eight main roots, which
“ extended every way in a hemiſphere, about
“ nine inches from the ſtem and main roots.

“ In order to get an eſtimate of the length
“ of all the roots, I took one of the main roots,
“ with its laterals, and meaſured and weighed
“ them; and then weighed the other ſeven roots,
“ with their laterals; by which means I found
“ the ſum of the length of all the roots to be no
“ leſs than 1448 feet.

“ And ſuppoſing the periphery of theſe roots,
“ at a medium, to be 0.131 of an inch, then
“ their ſurface will be 2276 ſquare inches, or
“ 15.8 ſquare feet; that is equal to 0.4. of ſurface
“ of the plant above ground.

" If, as above, twenty ounces of water, at a " medium, perſpired in twelve hours day, (*i. e.*) " thirty-four cubick inches of water, (a cubick " inch of water weighing 254 grains) then the " thirty-four cubick inches divided by the ſur- " face of all the roots, is=2286 ſquare inches " (*i. e.*) $\frac{34}{2286}$ is=$\frac{1}{67}$; this gives the depth of " water imbibed by the whole ſurface of the " roots, *viz.* $\frac{1}{67}$ part of an inch.

" And the ſurface of the plant above ground " being 5616 ſquare inches, by which dividing " the thirty-four cubick inches, *viz.* $\frac{34}{5616}=\frac{1}{165}$, " this gives the depth perſpired by the whole " ſurface of the plant above ground, *viz.* $\frac{1}{165}$ " part of an inch.

" Hence, the velocity with which water en- " ters the ſurface of the roots to ſupply the ex- " pence of perſpiration, is to the velocity with " which their ſap perſpires, as 165:67, or as " $\frac{1}{67}$: $\frac{1}{165}$, or nearly as 5:2.

" The area of the tranſverſe cut of the mid- " dle of the ſtem is a ſquare inch; therefore " the areas, on the ſurface of the leaves, the " roots and ſtem, are 5616, 2276. 1.

" The velocities in the ſurface of the leaves, " roots, and tranſverſe cut of the ſtem, are

" gained by a reciprocal proportion of the " ſurfaces.

$$\text{Area of}\left\{\begin{array}{l}\text{leaves}=5616\\ \text{roots}=2276\\ \text{ſtem}=\quad 1\end{array}\right| \text{velocity} \left|\begin{array}{r}=\frac{1}{5616}\\ =\frac{1}{2276}\\ =1\end{array}\right\}\text{or as}\left\{\begin{array}{l}\frac{1}{165}\text{ inch.}\\ \frac{1}{67}\text{ inch.}\\ 34\text{ inch.}\end{array}\right.$$

" Now, their perſpiring 34 cubick inches in " twelve hours day, there muſt ſo much paſs " through the ſtem in that time; and the velocity " would be at the rate of 34 inches in " twelve hours, if the ſtem were quite hollow."

" In order therefore to find out the quantity " of ſolid matter in the ſtem, July 27, at 7. " *a. m.* I cut up even with the ground a ſunflower; it weighed 3 pounds; in thirty days it " was very dry, and had waſted in all 2 pounds " 4 ounces; that is $\frac{3}{4}$ of its whole weight: ſo " here is a fourth part left for ſolid parts in the " ſtem; (by throwing a piece of green ſun-flower ſtem into water, I found it very near of " the ſame ſpecifick gravity with water) which " filling up ſo much of the ſtem, the velocity " of the ſap muſt be increaſed proportionably, " *viz.* $\frac{1}{3}$ part more, (by reaſon of the reciprocal proportion) that 34 cubick inches " may paſs the ſtem in twelve hours; whence " its velocity in the ſtem will be 45$\frac{1}{3}$ inches in

" twelve hours, ſuppoſing there be no circu-
" lation, nor return of the ſap downwards.

" If there be added to 34, (which is the leaſt
" velocity) $\frac{1}{3}$ of it $= 11\frac{1}{3}$, this gives the greateſt
" velocity, *viz.* $45\frac{1}{3}$. The ſpaces being as
3 : 4. the velocities will be 4 : 3 : : $45\frac{1}{3}$: 34.

" But if we ſuppoſe the pores in the ſur-
" face of the leaves to bear the ſame propor-
" tion as the area of the ſap-veſſels in the ſtem
" do to the area of the ſtem; then the velocity
" both in the leaves, root, and ſtem, will be in-
" creaſed in the ſame proportion.

" A pretty exact account having been taken
" of the weight, ſize, and ſurface of this plant,
" and of the quantities it has imbibed and per-
" ſpired, it may not be improper here to enter
" into a compariſon of what is taken in and per-
" ſpired by a human body, and this plant.

" The weight of a well-ſized man is equal to
" 160 pounds: the weight of the ſun-flower is
" 3 pounds; ſo their weights are to each other
" as 160 : 3, or as 53 : 1.

" The ſurface of ſuch human body is equal
" to 15 ſquare feet, or 2160 ſquare inches.

" The ſurface of a ſun-flower is 5616 ſquare " inches; ſo its ſurface is, to the ſurface of a " human body, as 26 : 10.

" The quantity perſpired by a man in twenty- " four hours is about 31 ounces, as Dr. Keill " found. *Vid. Medic. Stat. Britan.* p. 14.

" The quantity perſpired by the plant, in the " ſame time, is 22 ounces, allowing two ounces " for the perſpiration of the beginning and end- " ing of the night in July, *viz.* after evening, " and before morning weighing, juſt before and " after night.

" So the perſpiration of a man to the ſun- " flower is as 141 : 100.

" Abating the ſix ounces of the thirty-one " ounces, to be carried off by reſpiration from " the lungs in the twenty-four hours; (which " I have found by certain experiment to be ſo " much, if not more) the twenty-five ounces " multiplied by 438, the number of grains in " an ounce *avoirdupois*, the product is 10,950 " grains; which divided by 254, the number " of grains in a cubick inch of water, gives " 43 cubick inches perſpired by a man: which divided by the ſurface of his body, *viz.* 2160 ſquare inches, the quotient is nearly $\frac{1}{50}$ part of a cubick inch perſpired off a ſquare inch in twenty-four hours. Therefore in equal ſurfaces, and equal times, the man perſpires $\frac{1}{50}$, the plant $\frac{1}{165}$, or as 50 : 15.

“ Which exceſs in the man is occaſioned by the very different degrees of heat in each: for the heat of the plant cannot be greater than the heat of the circumambient air, which heat in ſummer is from 25 to 35 degrees above the freezing point; but the heat of the warmeſt external parts of a man's body is 54 ſuch degrees, and the heat of the blood 64 degrees; which is nearly equal to water heated to ſuch a degree as a man can well bear to hold his hand in, ſtirring it about; which heat is ſufficient to make a plentiful evaporation.

“ *Qu.* Since then the perſpirations of equal areas in a man and a ſun-flower are to each other as 165 : 50, or as $3\frac{1}{5}$: 1; and ſince the degrees of heat are as 2 : 1, muſt not the ſum or quantity of the areas of the pores lying in equal ſurfaces, in the man and ſun-flower, be as $1\frac{1}{3}$: 1? for it ſeems that the quantities of

“ the evaporated fluid will be as the degrees of “ heat, and the ſum of the areas of the pores, “ taken together.

“ Dr. Keill, by eſtimating the quantities of “ the ſeveral evacuations of his body, found “ that he eat and drank, every 24 hours, 4 “ pounds 10 ounces.

“ The ſun-flower imbibed and perſpired in “ the ſame time 22 ounces; ſo the man’s food, “ to that of the plant, is as 74 ounces to 22 “ ounces, or as 7 : 2.

“ But, compared bulk for bulk, the plant “ imbibes 17 times more freſh food than the “ man: for deducting 5 ounces, which Dr. “ Keill allows for the *fæces alvi*, there will re- “ main 4 pounds 5 ounces of freſh liquor, which “ enters a man’s veins; and an equal quantity “ paſſes off every 24 hours. Then it will be “ found, that 17 times more new fluid enters “ the ſap-veſſels of the plant, and paſſes off in “ 24 hours, than there enters the veins of a man, “ and paſſes off in the ſame time.

“ And ſince, compared bulk for bulk, the “ plant perſpires 17 times more than the man,

" it was therefore very neceſſary, by giving it " an extenſive ſurface, to make a large proviſion " for a plentiful perſpiration in the plant, which " has no other way of diſcharging ſuperfluities; " whereas there is proviſion made in man, to " carry off above half of what he takes in, by " other evacuations.

" For ſince neither the ſurface of his body " was extenſive enough to cauſe ſufficient exhalation, nor the additional reek, ariſing from " the heat of his blood, could carry off above " half the fluid which was neceſſary to be diſcharged every 24 hours; there was a neceſſity " of providing the kidneys to percolate the " other half through.

" And whereas it is found that 17 times more " enters, bulk for bulk, into the ſap-veſſels of " the plant, than into the veins of a man, and " goes off in 24 hours: one reaſon of this " greater plenty of freſh fluid in the vegetable " than the animal body, may be, becauſe the " fluid which is filtrated through the roots " immediately from the earth, is not near " ſo full freighted with nutritive particles " as the chyle which enters the lacteals of

" animals; which defect it was neceſſary to " ſupply by the entrance of a much greater " quantity of fluid. And the motion of the " ſap is thereby much accelerated, which in the " heartleſs vegetable would otherwiſe be very " ſlow; it having probably only a progreſſive " and not a circulating motion, as in animals. " Since then a plentiful perſpiration is found ſo " neceſſary for the health of a plant or tree, it is " probable that many of their diſtempers are " owing to a ſtoppage of this perſpiration, by " inclement air.

" The perſpiration in men is often ſtopped " to a fatal degree; not only by the inclemency " of the air, but by intemperance, and violent " heats and colds. But in the more temperate " vegetable, perſpiration can be ſtopped only " by inclement air; unleſs by an unkindly ſoil, " or want of genial moiſture, it is deprived of " proper or ſufficient nouriſhment.

" As Dr. Keill obſerved in himſelf a conſi- " derable latitude of degrees of healthy perſpi- " ration, from a pound and a half to 3 pounds; " I have alſo obſerved a healthy latitude of " perſpiration in this ſun-flower, from 16 to 28 " ounces, in twelve hours day. The more it

“ was watered, the more plentifully it perſpi-
“ red, *(cæteris paribus)* and with ſcanty watering
“ the perſpiration much abated.”

From theſe accurate experiments, it is evident that vegetables inſpire and expire. Pure air is neceſſary for animals. Vegetables require the ſame. When obliged to breathe their own vapours, they become unhealthy. For that reaſon corn is ſeldom good in ſmall incloſures; neither are trees healthy when much crouded. The ſuperior goodneſs of the grain produced by the drill and alternate huſbandry, evinces the neceſſity of a free circulation of air. There is a certain height to which the ſoil ought to raiſe the ears of corn. When, from too much cloſeneſs, they are elevated beyond that pitch, the real nouriſhment that ſhould go to the grain, is ſpent upon the ſtraw. The ſtems alſo, that ſhould have been hardened by the air, become weak, and unable to ſtand againſt more moderate ſtorms of wind and rain.

The culture of beans ſhews the truth of this obſervation. When ſown too thick, they puſh themſelves upward with ſeeming vigour, and the crop has the appearance of being a good one. But when examined, we find the pods ſmall, and few in number. On the contrary, when ſown in drills, with proper intervals, the ſtraw is ſhorter, and the pods much larger, and more numerous. I do not argue for the drill huſbandry in general; but with regard to beans, it is a rational and profitable practice.

Farmers may object to the difficulty of keeping the intervals clear of weeds. When hoers cannot be procured, ſheep are excellent weeders. The intervals, however, are beſt cleaned by the common horſe-hoe. A drill crop of beans is always ſuperior to a crop ſown by the hand.— But to return to our philoſophical argument.

The analogy that ſubſiſts between plants and animals, has induced ſome very eminent naturaliſts to ſuppoſe a regular circulation of the vegetable juices. M. Perrault, M. Major, M. Marriotte, Malpighi, and our countryman Grew, contended, much about the ſame time, for the circulation of the ſap. According to their microſcopical obſervations, the wood of trees, and the fleſh of plants, conſiſt of fine capillary tubes, which run parallel from the root, through the trunk and branches. Theſe they looked upon as arteries. Other minute veſſels were obſerved running between the wood and inner bark, which they diſtinguiſhed by the name of Veins. They alſo deſcribed, very correctly, the Tracheæ, or air-veſſels, which take their courſe through the fibres of the wood.—Theſe anatomical preliminaries being ſettled, they proceeded to reaſon in this manner.

The root having abſorbed a quantity of juice from the earth, it is made to aſcend thro' the veſſels of the wood, by the alternate expanſion and contraction of the Tracheæ, aſſiſted by the natural abſorption of the ſap-veſſels themſelves. They ſuppoſed the ſap to be rarefied to the degree of a fine vapour, in which ſtate it mounted upward to the extreme parts of the plant, where, meeting with the external air, it became condenſed into a liquor, and in that form returned to the root by the venal ſyſtem, between the wood and bark. Dr. Hales, in the moſt ſatisfactory manner, ſet aſide this doctrine, and ſubſtituted another in its place, more conſonant to reaſon and experiment.

It is ſomething remarkable that Dr. Hervey ſhould have been the firſt who eſtabliſhed the *circulation* of the blood, in oppoſition to moſt of the anatomiſts in Europe; and that Dr. Hales ſhould have clearly diſproved the *circulation* of the ſap, contrary to the opinion of almoſt every naturaliſt of his time.

In order that we may have a diſtinct view of the motion of the ſap, it will be neceſſary to reflect, that the root, ſtem, branches, and leaves are conſtructed in the ſame manner. Sallows, willows, vines, and moſt ſhrubs, will grow in an inverted ſtate, with their tops downward in the earth. Dr. Bradley deſcribes the manner of inverting a young cherry-tree, the roots of which will put forth leaves, and the branches become roots. Hence it is obvious that the nutritive matter may be conveyed as well by the leaves as the roots, their vaſcular ſtructure being the very ſame.

We have now ſettled the anatomical ſtructure of a plant. Upon it depends much of what we know of the vegetable œconomy. The motion of the ſap comes next to be examined.

During the heat of a ſummer's day, all plants perſpire freely from the pores of their leaves and bark. At that time the juices are highly rarefied. The diameters of the Tracheæ, or air-veſſels, are enlarged, ſo as to preſs upon and ſtraiten the veſſels that carry the ſap. In conſequence of which their juices, not being able to eſcape by the roots, are preſſed upward, where there is the leaſt reſiſtance, and perſpire off the excrementitious parts by the leaves and top-branches, in the form of vapour. When the ſolar heat declines, the Tracheæ are contracted. The ſap-veſſels are enlarged, and the ſap ſinks down in the manner of the ſpirits of a thermometer. In conſequence of this change, the capillary veſſels of the leaves and top-branches become empty. Being ſurrounded with the humid vapours of the evening, they fill themſelves from the known laws of attraction, and ſend down the new-acquired juices to be mixed with thoſe that are more elaborated.

As ſoon as the ſun has altered the temperature of the air, the Tracheæ become again diſtended, and the ſap-veſſels are ſtraitned. The ſame cauſe always produces the ſame effect; and this alternate aſcent and deſcent, through the ſame ſyſtem of veſſels, continues as long as the plant ſurvives.

The irregular motion of the ſtem and branches, is another cauſe that contributes to the aſcent of the ſap. Every time that theſe parts are acted upon by the air, they are made to aſſume a variety of angles, whereby the ſap-veſſels are ſuddenly ſtraitned. The contained juices conſequently receive reiterated impulſes, ſimilar to what happens to the blood of animals from the contraction of the heart. This obſervation may aſſiſt us in inveſtigating the vegetable œconomy, ſo far as it regards the management of fruit-trees; and probably may be extended throughout the whole ſyſtem of gardening, planting, and farming.

It may be objected, that trees fixed to the wall do, notwithſtanding, carry their ſap to the extreme branches; but it ſhould be conſidered that the warmth of their ſituation, aſſiſted by the horizontal direction of their branches, is fully ſufficient to propel the ſap, without the undulatory motion that I have mentioned.

I beg leave to obſerve, that theſe obſervations are only intended to convey a general idea of the motion of the ſap. It varies according to the temperature of the weather. The air is ſeldom one moment alike. The ſap muſt therefore ſometimes move quick, ſometimes ſlow. It may riſe and fall many times in a day. Sudden heats puſh it upward, ſudden colds make it fall. Thus the juices are blended, and the ſecretions forwarded.

The manner that the nutritive juices of the earth and atmoſphere are conveyed into the ſap-veſſels, remains to be deſcribed. And this makes a neceſſary part of our preſent argument, as it may aſſiſt us in finding out, and explaining, the diſeaſes of plants from the variations of the weather.

The outer bark which covers every external part of a vegetable, as well below as above the ſurface, is full of perſpiratory or abſorbent holes. The veſſels of this bark being endowed with the power inherent in capillary tubes, draw up the moiſture that is applied to their ſurface. From them it is committed to the veſſels of the inner bark. After receiving ſome degree of melioration, the ſap is delivered to the blea. From the blea, it paſſes, by anaſtomoſing canals, to the vaſcular ſeries. From thence to the wood, or fleſh, where it receives its laſt concoction.

The nutritive particles, being ſeparated by the mechaniſm of theſe numerous canals, are applied towards the fructification and increaſe of the plant; while the watery and excrementitious parts are carried expeditiouſly to the leaves, where they are perſpired off in the form of vapour. It is evident, however, that, as water contains but few particles that are fit for nouriſhment, it was neceſſary that plants ſhould have the power of imbibing a large portion of that fluid. For which reaſon the ſun-flower, conſidered bulk for bulk, takes in ſeventeen times more nouriſhment than a man, and conſequently perſpires more.

During the continuance of dry north-eaſt winds, the leaves of corn are obſerved to grow yellow, and the early-ſet fruit frequently falls off. This is owing to the want of moiſture in the atmoſphere to fill the veſſels of the leaves and top-branches, whereby the fruit is deprived of nouriſhment. Under ſuch circumſtances, it is probable that wall-fruit may be preſerved by prudently watering the leaves and top-branches during the heat of the day. It is, however, a ſingular happineſs that the air is at no time perfectly free from moiſture. Bring a bottle of cold water into the warmeſt room, and its ſurface will immediately be covered with a thick dew. An air abſolutely dry, would in a few days annihilate the vegetable creation.

The air is juſtly ſaid to contain the life of vegetables, as well as animals. It is a compreſſible and elaſtic fluid, ſurrounding the face of the globe, and reaching to a conſiderable height above it. Vegetables do not grow in vacuo, and animals die when deprived of air. It has two ſtates, being either elaſtic or fixed. Dr. Hales obſerves, that, in its elaſtic and active ſtate, it conduces to the invigorating the juices of vegetables; and, in its fixed and inert ſtate, gives union, weight, and firmneſs to all natural bodies. By his experiments we are informed, that fixed air conſtitutes near one third part of the ſolid contents of the heart of oak. It is found to bear the ſame proportion in peaſe, beans, and other vegetable ſubſtances. Heat and fermentation render it elaſtic. It is again capable of being abſorbed and fixed. Was the whole air of the univerſe brought at once into an elaſtic and repulſive ſtate, every thing would ſuffer a ſudden diſſolution. Was it entirely fixed, then all things would be reduced to an inert lump. Almighty providence has provided againſt theſe extremes, and in the moſt wonderful manner preſerves the balance.

Air is to be found in every portion of earth; and as it always contains a ſolution of the volatile parts of animal and vegetable ſubſtances, we ſhould be careful to keep our ſtiff ſoils as open as poſſible to its influence. It paſſes, both in its active and fixed ſtate, into the abſorbent veſſels of the root, and, mixing with the juices of the plant, circulates through every part. Dr. Hales, in his ſtatical experiments upon the vine, diſcovered it aſcending with the ſap in the bleeding ſeaſon.

Having demonſtrated that the Motion of the ſap depends upon the influence of the air, and the power of abſorption common to all capillary tubes, it naturally follows, that it cannot remain one moment at reſt. The gradations from heat to cold, and *vice verſa*, are infinite, and ſometimes deſultory. So muſt the motion of the ſap. From the combinations of the nutritive particles, a number of different fluids are prepared in the ſame plant. Matter is the ſame in all; but the modification of it makes things ſweet or ſour, acrid or mild.

The univerſal juice of a plant is a limpid ſubacid liquor, which flows plentifully from a wound made in a tree when the ſap is riſing.

The birch and the vine yield it in great abundance. This liquor, as it moves through the innumerable ſmall veſſels, becomes more and more concocted, and is the general maſs from which all the juices are derived. It may be called the blood of the plant. By a certain modification it produces high-flavoured oils, gums, honey, wax, turpentine, roſin, and even the conſtituent parts of the plant itſelf. How this tranſmutation is performed, remains, and perhaps ever will remain, unknown.

I hope it will not be objected to me, that in this eſſay I have been too minute. In the hiſtory of nature we cannot be too particular. Every part of it demands our moſt ſerious attention, and every part of it repays us for the labour we beſtow. The wings of the butterfly are painted by the ſame almighty hand that made the ſun. The meaneſt vegetable, and the moſt finiſhed animal, are equally the care of providence. We conſtantly view the wiſdom of God in his works; and yet, as the wiſe man obſerves, "hardly do we gueſs aright "at the things that are upon the earth, and "with labour do we find the things that are "before us."

ESSAY VII.

On a new Method of cultivating weak Arable Lands.

VArious are the methods recommended by huſbandmen for the cropping of their Lands. Some employ themſelves rationally in ſuiting the crops to the nature of the ſoil, while others follow the immemorial cuſtom of the village. All, however, agree in this, that a fallow is neceſſary; but they differ as to the time of its rotation. In the ſcheme of Agriculture upon good lands, recommended by Virgil, there is no change of ſpecies. Wheat and fallow ſucceed each other. Collumella obſerves the ſame thing. This ſeems to have been the foundation of the drill and horſe-hoeing huſbandry; a ſcheme purſued with indefatigable diligence by Mr. Tull; but it requires ſo much nicety and attention, that I apprehend it never will be brought into general uſe. The principles, however, upon which it is founded ought to be underſtood by every farmer, as they will enable him to reaſon properly upon ſome of the moſt intereſting operations of Agriculture, and lead him inſenſibly to neatneſs in the management of his farm. I do not mean that he ſhould adopt the theory of Mr. Tull. I would have him only reaſon upon his practice in regard to the deſtruction of weeds, and the looſening of the ſoil.

Reflecting, ſome years ago, upon the old and new huſbandry, I thought that a ſyſtem might be formed of a mixed nature, that would comprehend the advantages of both, without the inconveniences of either. I was the more deſirous of reducing my reaſoning into practice, as the plan ſeemed well adapted to the cultivation of weak arable lands that lie remote from manure.

I am ſenſible that, by the introduction of turnips and artificial graſſes, theſe weak lands may be cultivated in the moſt profitable manner; but in wide-extended countries without a hedge, theſe improvements cannot eaſily be introduced.

It will be almoſt unneceſſary to obſerve, that arable lands have ever been reſtored by means of a fallow, which the judicious huſbandman makes more or leſs frequent in proportion to the poverty of the ſoil. Upon the high Wolds in Yorkſhire, where the ſoil is poor and thin, oats and barley are principally cultivated. The uſual huſbandry in open field-land is one crop and a fallow; and in ſome places, where there is a greater poverty of ſoil, they are content with a ſingle crop, and then let the land reſt for ſome years to recover itſelf.

Theſe appear unſatisfactory modes of cultivation. A few ſtraggling ſheep, that browſe upon the fallows, cannot reſtore to the earth what the weeds devour. Weeds and corn live upon the ſame food. To protect the latter we muſt deſtroy the former. Wherever abundance of weeds are obſerved upon the fallows, we may pronounce the huſbandry of the diſtrict to be feeble, the huſbandman poor, and the rents low. To remedy the defective cultivation of weak arable lands, I have adopted the following ſyſtem. My practice fully juſtifies the recommendation.

Inſtead of having the lands laid out in broad ridges, I order them to be made only nine feet wide. When the ſeed-time comes, I ſow every other land broad-caſt, and harrow in the grain in the uſual manner. The intermediate ſpaces, which I call the fallow lands, are plowed two or three times, at proper ſeaſons, by a light plow drawn by one horſe, in order to make a clean fallow for the ſucceeding crop. Upon theſe lands the ſeed is ſown as before. The ſtubble in turn becomes the fallow, and is treated accordingly. In this alternate way I manage weak arable lands, and I have the ſatisfaction to find that very little manure is required; which is a moſt agreeable circumſtance, as ſuch lands are generally remote from a large town. I dare venture to ſay, that the ſame field, managed in this alternate way for a few years, will be found to produce one third part more profit than when cultivated in the uſual manner.

Farmers that have large tracts of weak arable land, and live remote from dung, will find this mode both profitable and eaſy of application. I do not recommend it where the lands are deep and rich—or within a reaſonable diſtance of manure.

To account for the advantages of this culture, we need only reflect that vegetables, no more than animals, can ſubſiſt long in a ſtate of health without the free enjoyment of air. In a large field, when the weather is calm, the air remains in a ſtate of ſtagnation, whereby the perſpiration of the plants is permitted to continue too long upon the ears of corn. Hence many inconveniences ariſe to the crop. On the contrary, in the alternate huſbandry, the air is conſtantly in motion. The intermediate fallows ſerve as funnels to carry it off, and, along with it, all ſuperfluous moiſture.

In conſequence of this freedom of air, upon which I lay a great ſtreſs, the ears of corn are always obſerved to be well fed, and the ſtalks firm and ſtrong. When by ſevere weather the corn happens to be lodged, it is thrown upon a clean fallow, where it has no chance of being bound down by weeds. It is conſequently ſooner raiſed by the current of air which is conſtantly paſſing along the fallows.

It is, however, the particular happineſs of this method of cultivation, that the corn is ſeldom laid, even in the moſt ſtormy weather.

Turnips, or, when the ſoil is deep and ſandy, a few carrots or potatoes, may be placed upon the intermediate lands; but I have always found it beſt to keep them as perfect fallows. Every thing that grows takes ſomething from the ſoil; and as our land is ſuppoſed to be weak, and not ſupported with much manure, we ought not to ſuffer the ſmalleſt vegetable to take root upon it.

If the farmer chuſes he may vary his crops; but I am of opinion, and I ſpeak from ſome experience, that the ſame grain may be cultivated, as long as he pleaſes, upon lands managed in the manner that I have recommended. In conſequence of this happy diſpoſition of the ſoil, every kind of grain may be ſuited to the land moſt proper for it. I do not confine the alternate huſbandry to oats, barley, and rye. I have tried it upon good wheat land; and if the farmer attends to his buſineſs, he will find his wheat crops greatly to exceed his expectations. In the cultivation of this grain the utmoſt attention muſt be paid to the cleanneſs of the fallow lands. For want of proper care in that particular, I was once very unſucceſsful in an experiment of two acres.

In October 1769 I began an extenſive trial with wheat upon good land, and as I was deſirous of making two experiments at the ſame time, I manured the ſown lands with the oil-compoſt, at the rate of 9*s.* *per* acre, which, though an annual charge, may be conſidered as a trifling ſum. At preſent *(February)* the field looks well, and promiſes a plentiful crop. I ſhall minutely attend to every particular, that I may be able to communicate the experiment upon a future occaſion.

I acknowledge that many of the advantages of this culture are in common with the drill huſbandry; but I flatter myſelf that there are others which that ingenious ſyſtem does not enjoy.

I know it will be objected, that in this manner the fallows will be loſt to the ſheep during the ſummer months. I anſwer, ſo much the better. If poſſible, the fallows ſhould not be permitted to bear a ſingle leaf. The farmer ought to find other ways to ſupport his ſheep, and, if he is an intelligent man, he will readily do it. It is an odd kind of huſbandry, when the fields bear corn one year for the owner, and the next weeds for his ſheep.

When firſt I practiſed this new culture, I was apprehenſive that the pigeons and crows would prove my greateſt enemies, by ſettling upon the fallow lands, and pulling down the ears of corn. I have now the pleaſure to aſſure the public, that, after ſome years experience, I find my lands no more liable to thoſe depredations than the neighbouring ones.

I need not obſerve that, by this ſyſtem of huſbandry, the lands are rendered open and light. In conſequence of which abundance of nouriſhment will be conveyed into the body of the ſoil, inſtead of being left upon the ſurface to be exhaled by the ſun, or ſwept off by the winds. But as the beſt things ſometimes bring inconveniences with them, it will be neceſſary to correct this looſeneſs of the ſoil by rolling the lands at proper ſeaſons. For this the huſbandman needs no directions.

I have the ſatisfaction to find that incloſures are begun upon the Lincolnſhire and Yorkſhire Wolds; in conſequence of which a greater quantity of corn will be produced for a few years than formerly. To ſuch gentlemen as have eſtates in thoſe Counties, or in ſimilar ones, I beg leave to recommend the alternate huſbandry. I dare venture to ſay, that, in point of profit and convenience, it will be found greatly ſuperior to the drill huſbandry. The implements uſed are thoſe of the country, and the mode of cultivation is within the capacity of the meaneſt plowman.

ESSAY VIII.

On the Riſe and Aſcent of Vapours.

IN the Philoſophical Tranſactions, vol. 59, for the year 1769, is inſerted a paper upon the different quantities of rain which fell at different heights over the ſame ſpot of ground, by William Heberden, M. D. F. R. S. in which he ſays, "What may be the cauſe of this extra-"ordinary difference has not yet been diſco-"vered. It is probable that ſome hitherto un-"known property of electricity is concerned "in this phænomenon."

I have often thought that the true cauſe of the aſcent of vapours in the air, which form meteors, hath not yet been diſcovered, or, at leaſt, enough attended to; and, of conſequence, many phænomena attending thereon appear unaccountable and intricate. Having frequently, of late, given ſome attention to this ſubject, I am inclined to believe that, by conſidering it in a new point of view, ſome light may be thrown upon it.

Various have been the opinions of Philoſophers in their attempts to account for the aſcent of vapours from the earth, their ſuſpenſion in the air, forming clouds, rain, &c. Each hypotheſis has had its followers; but many of their data being falſe, and not agreeable to nature, their endeavours fell, in courſe, ſhort of their expectations. I ſhall juſt mention two or three which have been the moſt generally received.

The Carteſians tell us, that the particles of water are formed into hollow ſpherules by the ſolar heat; theſe, being filled with ſubtile matter, become lighter than air, and are eaſily buoyed up in it. But as we are now aſſured that this *materia ſubtilis* has no foundation in nature, all reaſoning from it is to be rejected.

Dr. Nieuwentyt, and ſeveral others, in order to account for the aſcent of water in air, a fluid ſo much lighter than itſelf, imagined that particles of fire, ſeparated from the rays of the ſun, and adhering to the particles of water, make, together, little bodies lighter than an equal bulk of air, which muſt therefore riſe therein, till they arrive at ſuch an height as to meet with air of the ſame ſpecific gravity with themſelves, forming there a thin cloud. They ſuppoſed that rain was produced by the ſeparation of thoſe particles of fire from the water, whereupon the latter coaleſce, and deſcend, according to their own gravity, in drops of rain or dew. A ſmall degree of conſideration will prove this hypotheſis to be erroneous. We need only to reflect that heat muſt alſo be generated by ſuch a combination, and we ought to be ſenſible of an extraordinary degree of warmth in paſſing through a cloud, whereas the vapour is really colder than rain itſelf; heat ſhould likewiſe, according to this theory, be produced by evaporation; but we find it, on the contrary, to generate cold to an exceſſive degree.

Another opinion concerning the riſe and ſuſpenſion of vapours, is, that though water be many times ſpecifically heavier than air, yet if the ſurface of it be encreaſed, by greatly diminiſhing the bulk of its particles, it cannot eaſily fall; ſince the weight of each particle is known to diminiſh in proportion to the cube of its diameter; whereas the ſurface, to which the air reſiſts, decreaſes only as its ſquare; and this is ſufficiently evident from the floating of duſt, motes, and other light bodies for a time therein, according as they are more or leſs minute. To be convinced of the inſufficiency of this notion, we need only conſider, that the riſing of duſt, &c. in the air, is conſtantly owing to the application of ſome external force; whereas vapours are always riſing, as well in calm as windy weather, neither do they fall to the ground, or ſubſide, when the wind ceaſes, unleſs under certain conditions, and the air is always loaded with them.

The moſt generally received opinion is, that, by the action of the ſolar heat on the ſurface of the water, the aqueous particles are formed into globules filled with a flatus, or warm air. They are thus rendered ſpecifically lighter than common air, and muſt riſe therein, till they meet with ſuch as is of equal ſpecific gravity with themſelves. But we are well aſſured that there can be no flatus within theſe globules, warmer or more rarefied than the air that ſurrounds them, as the action of the ſun is equal in ſtrength on every part of the ſurface; and if they could be formed, their exiſtence would be only momentary, as we ſee in the bubbles of ſoaped water, when blown up by the warm air from the lungs; nay, ſoaped water is much more tenacious than common water, and muſt, conſequently keep the air longer incloſed. To the formation of theſe bubbles a warm air from the lungs is required; on the contrary, as we have mentioned above, cold is generated by evaporation.

Dr. Deſaguliers, after endeavouring to confute the theories mentioned above, advances the following one of his own. He obſerves, with Sir Iſaac Newton, that when the particles of a body are ſeparated from their contact by heat or fermentation, their repulſive force grows ſtronger, and they exert that force at greater diſtances; ſo that the ſame body may be expanded into a very large ſpace by becoming fluid, and may ſometimes take up more than a million of times the room it did in a ſolid ſtate. Thus, when the particles of water are turned into vapour, they repel each other ſtrongly, and, at the ſame time, repel air more than they repel each other. Aggregates of ſuch particles, made up of vapour and vacuity, according to this theory, will eaſily riſe in air of different denſities, as they are more or leſs attenuated by heat. He obſerves that heat acts more powerfully on water than on common air; for that the ſame degree of heat, which rarefies air two thirds, will rarefy water near 1400 times, changing it into ſteam or vapour as it boils it. And, in winter, the ſmall degree of heat, which, in reſpect of our bodies, appears cold, will raiſe a ſteam or vapour from water, at the ſame time that it condenſes air. Alſo, that the denſity or rarity of this vapour depends chiefly on its degree of heat, and but little on the preſſure of the circumambient air. From which he infers, that the vapour being more rarefied near the ſurface of the earth, than the air is by the ſame degree of heat, it muſt neceſſarily be buoyed up into the atmoſphere; and ſince it does not expand itſelf much, though the preſſure of the incumbent air grows leſs, it at length finds a place where the atmoſphere is of the ſame ſpecific gravity with itſelf, where it floats, till, by ſome accident or other, it is converted again into drops of water, and falls down in rain.

We may remark, that in all the theories above-mentioned, fire is looked upon as the principal or ſole agent in the formation and aſcent of vapours. Dr. Deſaguliers gives the following experiment, to prove that air is not neceſſary for the formation of ſteam or vapour.

" Take a pretty large veſſel of water, which muſt be ſet upon the fire to boil. In this veſſel muſt be ſuſpended a glaſs bell, made heavy enough to ſink in water; but put in in ſuch a manner, that it be filled with water when upright, ſo that no bubbles of air be left within. As the water boils, the bell will, by degrees, be emptied of its water, the water in the bell being preſſed down by the ſteam which riſes from it; but as that ſteam has the appearance of air, in order to know whether it be air or not, take the veſſel off the fire, and draw up the bell till only the mouth remains under water; then, as the ſteam condenſes by the cold air on the outſide of the bell, the water will riſe up into the bell, quite to the top, without any bubble above; which ſhews that the ſteam, which kept out the water, was not air."

But the Doctor was not aware, that the riſing of the bell in this experiment, which he ſuppoſed to be from the ſteam, is, in reality, owing to air diſcharged from the water in boiling, and which is reabſorbed by the water whilſt cooling. See Experiments by the Hon. Henry Cavendiſh, F. R. S. Philoſoph. Tranſact. Anno 1766.

The riſe and aſcent of vapours into the atmoſphere, is looked upon, by all Philoſphers, as a kind of natural diſtillation. This idea is, indeed, a neceſſary conſequence of every hypotheſis, in which the action of fire is eſteemed the principal agent. In which caſe, fire, ſolar and ſubterraneous, by joining with, or increaſing the repellency of the particles of fluids, renders them capable of riſing in the air, as vapours in an alembic; after which the coldneſs of the air condenſes them, in the manner of the refrigeratory in common diſtillation; hence they deſcend, in the form of rain, upon the ſurface of the earth.

But we muſt obſerve, that a conſiderable degree of heat is neceſſary to effect this; nay, very little vapour is ſeen to riſe in the ſtill till the water actually boils; it is alſo quickly condenſed, nor is it capable of being much diffuſed in the air. For although the water in the refrigeratory be grown very hot, you will ſcarce perceive the leaſt vapour come from the mouth of the worm; the whole ſeems intirely condenſed into water: Whereas we ſee that vapours are raiſed from the earth in places moſt remote from the action of the ſun, and far removed from the influence of ſubterraneous heat; here the ſuppoſed powerful action of fire, is, I preſume, totally inadequate to the effect.

Vapours are continually riſing in wet caverns and ſubterraneous places, to which little heat can have acceſs. Theſe are ſometimes formed into ice. In the Memoirs of the Academy of Sciences, we are told that in September, 1711, near Baſançon, there were found three pyramids of ice, fifteen or ſixteen feet high, and five or ſix in circumference, in a cavern eighty feet deep, the bottom of which was covered with three feet of ice: And we know that all grottos and caverns under ground, are conſtantly found very damp and moiſt. Vapours alſo riſe in great quantities from ice itſelf; though kept in very cold places, and remote from the influence of the ſun.

We are hence certain, that evaporation goes on in places where the rays of the ſun never reach; the dampneſs, coldneſs, and ice found in theſe ſubterraneous manſions, ſhew no degree of heat in any degree anſwerable to the effect, as being the immediate cauſe of the riſe of vapours.

In Greenland, during the abſence of the ſun, or winter ſeaſon, when the cold was ſo intenſe as to raiſe bliſters on the ſkin, and to congeal brandy, the air was very miſty, cloudy, and heavy ſnows fell; hence we find a conſiderable aſcent of vapours where the action of heat was extremely weak and confined.

If it could be allowed that the aſcent of vapours depended ſolely upon the action of heat, it would then appear impoſſible that they could be able to riſe any conſiderable height into the air. We know that the vapours in diſtillation are condenſed, even when every part of the apparatus is become very hot; this muſt happen to vapours before they arrived at any conſiderable height.

If you aſcend a high mountain in a hot ſultry day, at the ſummit you will ſhudder with cold, the plains below being at the ſame time parched up with heat.

In many parts of the torrid zone, where they faint in the valley under a vertical ſun, the higheſt mountains are frequently covered with ſnow; the ſummits produce variety of plants and animals: there muſt be, from thence, a conſiderable and conſtant evaporation.

If the aſcent of vapours was alone cauſed by the action of heat, they could only be diffuſed through the air; and I preſume that, if this was the caſe, it would be impoſſible but that the tranſparency of the air muſt be deſtroyed; ſo great a quantity of ſteam would never ſuffer us to ſee the celeſtial bodies; nay, the rays of light could not but be ſo variouſly refracted, as to prevent our ſeeing any object upon the ſurface of the earth diſtinctly, as in thick miſts.

The quantity of water in the atmoſphere, at all times, is prodigious; and of this we may form a tolerable idea from the following conſiderations:

Firſt, The quantity of fluid exhaled from animal bodies. Sanctorius found, that the quantity exhaled from a human body, in the ſpace of twenty-four hours, amounted to near five pounds in weight; how great muſt the quantity be from the whole race of mankind! We muſt take into this account the quantity of perſpiration from the whole animal creation.

Secondly, The quantity of exhalation from vegetables. Dr. Hales ſays, from experiments, that the middle-rate perſpiration from a ſun-flower, three feet and a half high, in the ſpace of twelve hours, in a very dry day, was one pound four ounces avoirdupois weight; from which ſome degree of judgment may be formed of the great quantity of fluid daily exhaled from vegetables.

Thirdly, The immenſe quantity of exhalation from the water upon our globe. Dr. Hally, by obſerving the quantity evaporated from a veſſel full of water of the ſame degree of ſaltneſs with that of the ocean, calculated, that the quantity exhaled from the Mediterranean Sea only, in one ſummer's day, there being little wind, amounted to 5,280,000,000 tons of water.

If we conſider how thick and denſe the vapours hang over water, when heated, I think it will appear very evident that, if the aſcent of vapours from the earth was owing to the ſame cauſe, we could never be able to have a diſtinct view of any object upon the ſurface of our globe.

Was the aſcent of vapours owing to the immediate influence of fire, a ſenſible heat muſt be perceived, as the ſteam riſing from water, under that circumſtance, is very hot; on the contrary, we find a conſiderable degree of cold is produced by natural evaporation.

Dr. Franklin made the following experiment upon this ſubject. The ball of a thermometer was repeatedly and alternately wetted with æther, and blown up with a pair of bellows to quicken the evaporation; by which means the included liquor deſcended from ſixty-five degrees, the heat of the air at that time, down to ſeven; that is, twenty-five degrees below the freezing point. The bulb, at the end of the experiment, was covered near one fourth of an inch thick with ice, proceeding either from water mixed with æther, or from the breath of the aſſiſtants.

Any one may obſerve that immediately after coming out of a bath, or waſhing the hands in water, a remarkable coldneſs is felt, unleſs the ſkin be well dried with a napkin; hence the neceſſity of drying the body very well after the uſe of baths, fomentations, &c.

This experiment not only ſhews cold to be produced by evaporation, but that this proceſs goes on in an extream degree of cold.

From theſe experiments we are led to conclude, that heat cannot be, as hath been univerſally agreed to, the chief and primary agent in the aſcent of vapours. Some other power muſt then be diſcovered to elucidate this phænomenon.

I flatter myſelf that the following theory will be found leſs exceptionable than any other hitherto given.

The Cauſe of the Riſe and Aſcent of Vapours.

I preſume that the riſe and ſuſpenſion of vapours is owing to the power of the air as a menſtruum, capable of diſſolving, ſuſpending, and intimately mixing the particles of water with itſelf.

All fluids are capable of diſſolving particular bodies, and as the air is a fluid we may conclude it to poſſeſs that property.

The Hon. Mr. Boyle found, from experiments, that there were no exhalations from liquors in vacuo, but as ſoon as the air was let into the receiver, they roſe up plentifully.

We know, from experiments, that the air contains, at all times, and in every part, a large quantity of water.

In this ſolution it appears, that an intimate union, or proper mixture, takes place between the aerial and aqueous particles, by which a compound is produced, perfectly clear and tranſparent, fit for the tranſmiſſion of the rays of light, and adapted to the œconomy of the animal and vegetable creation.

All menſtruums are confined in their action, and can only take up a certain proportion of the ſolvend; when they have performed that, they are in a ſaturated ſtate, and incapable of ſuſpending more; if in this ſtate the ſolution be any way weakened, a proportionate quantity of the ſuſpended matter ſeparates from the menſtruum, and is precipitated.

The power and effect of all ſolvents is increaſed, in ſome degree, by heat, agitation, and the greater extenſion of the ſurface of the matter acted upon; and, by the contrary of theſe, their power is rendered weaker, and more confined.

As the air of our atmoſphere is a perfect chaos of all kind of corpuſcles, a ſort of compound matter, conſiſting of air, water, emanations and exhalations from the three kingdoms of nature, we cannot have any certain idea of its nature and action in its moſt ſimple ſtate. We muſt therefore at preſent be content with reaſoning from analogy; and, if we are by that made capable of accounting for the various phænomena attending the riſe and aſcent of vapours, it will be a ſtrong preſumption that my theory has ſome foundation in nature.

I ſhall lay it down as a rule, that the air is always in a ſaturated ſtate, containing as much water as it can ſuſpend, or nearly ſo; it being only from accidental cauſes that its ſolvent power is made ſtronger or weaker, cauſing the various phænomena obſerved in our atmoſphere.

The air being reduced to the denſity which it has near the ſurface of the earth, by the weight of the ſuperincumbent air, is more or leſs compreſſed, according to the greater or leſs weight of the atmoſphere; hence the higher we go from the ſurface, the rarer is the air, as appears from experiments made with the barometer upon mountains. The greater the denſity of the air, the more powerful is its action as a menſtruum, as a greater quantity of ſolvent is applied in a given ſpace.

We may preſume, that the water upon the ſurface of the earth riſes up in conſequence of the attractive power of the air as a menſtruum, in which it becomes ſuſpended, an intimate combination taking place. The nearer the air to the ſurface, the more it will be ſaturated, but the watery particles are ſoon, by the attraction of the air above, diffuſed to a greater height, and this probably to the very ſummit of the atmoſphere: we are, however, certain of its preſence at the tops of the higheſt mountains. It may be obſerved that, let the miſts be never ſo thick near the ſurface, if we aſcend a high mountain the air is found to be clear, and the miſts are ſeen floating below. This may be illuſtrated by what happens in the making of tinctures; in which caſe, the veſſel being at reſt, the menſtruum becomes more highly impregnated the nearer it is to the ſurface of the ſolvend, but weaker and weaker the more remote from it.

Agreeable to this is an obſervation of Jacobus Zarabelli, given in Mr. Boyle's works.

"Contigit id meæ experientiæ, quod etiam aliis contigiſſe audivi, ut aſcenderim ad ſummitatem uſque montis Veneris, qui omnium in patavino agro altiſſimus eſt; ibi per totum diem habui aerem ſereniſſimum, ſed infra circiter medium montis vidi nubes, quæ me viſione vallium prohibebant, veſperi autum poſtquam de illo monte deſcendi, inveni factam eo die infera parte magnam pluviam, cum in montis cacumine nil pluiſſet."

Nay, it has been obſerved, that no rain fell upon the top of the cathedral at York, when there was ſmall drizzling rains with thick miſts in the ſtreets below. This only happens when the air is in a ſtate of ſtagnation. The particles of all ſolvends are more univerſally diffuſed by agitation of the menſtruum.

Have we not here an eaſy and natural ſolution of the phænomenon obſerved by Dr. Heberden, as mentioned at the beginning of this paper?

Of the Effect of Winds in aſſiſting and promoting the Riſe of Vapours.

I take the property of winds, in aſſiſting the ſolvent power of the air, to be analogous to the effect of agitation in other menſtruums. Their efficacy in drying up the water and moiſture in the fields, roads, and ſtreets, after heavy rains, and in damp weather, is obvious, and eaſily accounted for.

The air, as a menſtruum, when at reſt, can only take up and diſſolve a certain quantity of water; it becomes ſaturated and incapable of ſuſpending more; but, when agitated by winds, the ſaturated part is blown off from contact with the ſurface of the ſolvend, and a freſh quantity of unſaturated air is immediately applied thereto. By which means the proceſs of evaporation goes forward with great celerity, and the moiſture upon the ſurface of the earth is ſoon dried up.

In damp and low ſituations, ſuch as marſhes, bogs, and vallies ſurrounded by high mountains, there being no winds or agitation of the air, miſts and fogs are ſeen hanging like thick clouds; and in ſuch places the graſs and other vegetables appear loaded with drops of water, in conſequence of a precipitation of the overcharge of water in the air.

In damp weather, with a ſtagnant ſtate of the air, large towns and cities are obſerved, when viewed from a diſtance, to be covered with thick and almoſt impenetrable fogs, frequently hiding the whole from the ſight, except perhaps the tops of high ſpires of churches. In this ſtate of the air, the walls, ceilings of houſes, marble ſlabs, &c. become damp, and covered with drops of water.

When a briſk wind gets up, theſe miſts, or portions of over-ſaturated air, are carried off; in conſequence of which the moiſture is ſoon evaporated.

I have often, at four or five miles diſtance, obſerved the city of York obſcured by thick miſts, ſo as to prevent my ſeeing any part of it, except ſometimes the very ſummit of the cathedral; and a wind then ariſing, ſuch a quantity of over-ſaturated air was carried off, as to extend viſibly, and without interruption, to a village two miles diſtant, towards the contrary point from which the wind blew. The air was at that time ſo clear in every other part, that I was able diſtinctly to perceive the high roads over the hills at fifteen or twenty miles diſtance.

When the air is at reſt, or in a ſtate of ſtagnation, it becomes impregnated with water beyond ſaturation, and cannot combine with the overcharge; as this can be only diffuſed, it ſoon precipitates, and falls in the form of rain.

The air is, for the moſt part, but little agitated, with us, when the wind is ſoutherly; hence the reaſon why ſuch winds are moſtly attended with miſts and ſmall drizzling rains. In this caſe the rains are continual.

As the over ſaturation is only near the ſurface of the earth, the particles of water fall from a ſmall height, and not having opportunity to collect themſelves together, the rain muſt be ſmall and drizzling.

When a briſk wind blows, the over-charged portion of air is driven by the agitation of the whole maſs, in various directions; part is carried up to a conſiderable height, ſwims about, and, by refracting the rays of light into different directions, becomes viſible to us, forming clouds, which, ſoon loſing their equilibrium, fall in rain. As the length of the paſſage in falling gives the aqueous particles opportunity to collect together, large drops are generally formed. Hence appears the reaſon why ſhowers are uſually of ſhort continuance, ſudden in coming, ſeldom attended with miſts, and frequently intermixed with gleams of ſunſhine, in windy weather.

But as ſome winds, though boiſterous, bring with them, at times, a quantity of over-ſaturated air, they will, of courſe, be attended with miſts and drizzling rain; of this kind are the eaſterly winds with us, which blowing over a pretty large tract of ſea, come charged with moiſture. On the contrary, the north and weſterly winds are generally dry, and attended with fine weather.

From a proper conſideration of what is here advanced, a conſiderable light may be thrown upon agriculture.

Some lands naturally moiſt, though they may appear dry to a ſuperficial obſerver, are found to encourage the growth of particular plants without the trouble of watering. The cultivator immediately gives it as an infallible rule, that ſuch plants need not that aſſiſtance, in which he is ſoon followed by others glad to ſave the trouble and expence. In conſequence of which, another farmer plants in land naturally dry. The crop, for want of its neceſſary moiſture, diſappoints his expectation; he wonders at the effect, but never reflects upon the cauſe.

We ſhall inſtance this in the culture of cabbages. Mr. Young, in his Northern Tour, informs us that Mr. Scroope planted this vegetable in the great drought of 1765, without watering, and is poſitive that it is a needleſs trouble. He is followed by Mr. Crowe and Mr. Turner. The Marquis of Rockingham, Mr. Ellerker, and Mr. Tucker, on the contrary, found the advantage of watering in dry ſeaſons.

I ſhall not heſitate to ſay, that both theſe opinions, though capable of miſleading the ignorant farmer, are juſtly founded, the difference proceeding from the natural dryneſs and moiſture of the reſpective lands. Two cloſes, though contiguous, the one ſhall be found compoſed of a very moiſt and wet ſoil; the other, to as great an extreme, dry and parched. Nay, different parts of the ſame field are often found, in this reſpect, to vary greatly in their natures, nor is this always indicated by external appearances.

Without attending to this ſubject, agriculture will be for ever a vague and uncertain ſtudy. The endeavour to raiſe any particular plant by the ſame mode of culture, in all kinds of land, is as abſurd as to ſeek for the plant called pile-wort in the deſarts of Arabia.

I flatter myſelf that, if attention be given to what is laid down in this eſſay, the intelligent cultivator will be enabled to judge properly of the nature of his lands, regarding dryneſs and moiſture; his fields and gardens will evidence its utility.

The aſſiſtance of the botaniſt may in this caſe be of great advantage. A collection of the moſt common and obvious plants, natural to different ſoils and ſituations, engraven and digeſted under their proper diviſions, will be of great uſe in ſhewing the difference of ſoils in different places. A perſon, from a thorough knowledge of this ſubject, will become capable of giving a right judgment of the intrinſic value of any parcel of land, from a ſhort and tranſient view of it, and that with the greateſt exactneſs and certainty.

We know from experience, that vegetables do not ſolely depend upon their roots for a neceſſary ſupply of moiſture, but abſorb, thro' innumerable bibulous orifices diſperſed all over their ſurfaces, a great quantity of water from the atmoſphere.

This abſorption can only take place when the air is in an over-ſaturated ſtate; ſuffering, in conſequence of this, a degree of precipitation, forming rain, miſts, and dews. The higher the ſituation of any parcel of ground, *cæteris paribus*, the leſs will it be ſubject to miſts and dews, and *è contra.*

This *radical* and *ſuperficial* abſorption is an admirable proviſion of nature, and ſeems abſolutely neceſſary to the preſervation of vegetables, by affording them a conſtant and plentiful ſupply of moiſture.

Agreeable to this it is probable that the lands, on which Meſſ. Scroope, Turner, and Crowe planted their cabbages, were, from their ſituation, more liable to miſts and dews than thoſe where the Marquis of Rockingham, Meſſ. Ellerker and Tucker made their experiments.

The ſuperficial abſorption of the plants, in the firſt caſe, together with the ſupply of natural moiſture from the ſoil, proved ſufficient without the aſſiſtance of watering. But, in the other, for want of ſufficient moiſture in the ground, and a proper ſupply from the atmoſphere, the aſſiſtance of the planter became neceſſary.

We may, from hence, learn the bad conſequences of forming general rules from particular experiments. A mode of culture ſhall anſwer very well upon one particular piece of ground, which will be found fruitleſs in another, though contiguous, and apparently of the ſame quality. Such is the variety obſervable in the works of nature.

In order to obtain an exact knowledge of the nature of particular lands, as to their degree of moiſture, I would adviſe the cultivator not only to examine the ſoil itſelf, but alſo the probability of its being more or leſs ſupplied with water from the atmoſphere.

Beſides the methods in common uſe, I would viſit my ground in a hot ſummer's day a little before ſun-ſet, and carefully obſerve in what parts a miſt or fog firſt appears; this will always be, *cæteris paribus*, over the part or parts where there is the greateſt moiſture, and will be the more diſtinctly ſeen in proportion to the greater heat of the preceding day.

The ſame obſervation may be made in a ſummer's morning about ſun-riſe; for the damper the ground, the longer the miſts will be ſeen ſuſpended over it.

I have obſerved a great difference in this reſpect, in different parts of one and the ſame field.

The Effect of Heat in aſſiſting and promoting the Riſe of Vapours.

As heat contributes to the action of all menſtruums upon their ſolvends, we may conclude that it greatly aſſiſts the ſolvent power of the air upon water. The rationale of this remains yet to be diſcovered: we are, however, well acquainted with its effects.

If we diſſolve, in a ſand-heat, as much nitre in water as it will ſuſpend to ſaturation, and keep it in the ſame degree of heat, being ſecured from evaporation, it will for ever remain ſuſpended, and the ſolution be clear and limpid; but if it be taken out of the ſand-heat and expoſed to the open air, the ſolvent power being weakened, the over-charged part of the nitre is detached from the water, and ſhoots into cryſtals, adhering to the part of the phial to which the greater degree of cold is applied.

In ſummer, when the ſolar rays fall more perpendicular upon the earth, the ſolvent power of the air is greatly increaſed, and that, *cæteris paribus*, in proportion to the degree of heat: at this time a much greater quantity of vapours exhale from the ſurface of the earth. This, indeed, is not very obvious when conſidered in a ſuperficial manner, becauſe the air appears to be really dryer at ſuch ſeaſons than in winter; fluids ſooner evaporate, and leſs rain falls. But this, I preſume, is owing to the action of the air, as a menſtruum, rendered more powerful by the increaſe of heat, by which water is ſo immediately and intimately combined with it, as to eſcape our ſight. Thus the exhalations from the lungs are imperceptible in a hot ſummer's day, which in winter iſſue out in clouds.

It does not ſolely depend upon the coldneſs of the air, that the breath of animals becomes viſible therein: for we may obſerve this to be the caſe frequently when the air is warm and ſultry; nay, above ſummer's heat, as is indicated by the thermometer; but at ſuch times it is always very damp and miſty. This obſervation ſeems to corroborate our hypotheſis, in referring the riſe of vapours into the atmoſphere to the action of the air as a menſtruum; not to the immediate agency of heat, which ſeems to be only an aſſiſtant principle, by no means abſolutely neceſſary.

The air in the middle of ſummer, eſpecially when the ſun is not far removed from the meridian, is ſeldom over-ſaturated with moiſture, except in deep vallies, boggy and ſwampy ſituations, or when attended with cold winds, ſtormy weather, &c. In ſome very hot countries, far removed from the ſea, the ſurface of the earth being very dry, and the atmoſphere not liable to ſtorms and tempeſts, the air is never ſo over-ſaturated as to ſuffer any precipitation; hence it never rains.

The reflection of the ſolar rays from the ſurface of the earth, aſſiſts the action of the air upon water in ſome degree; but as this is confined meerly to the part near the ſurface, its action cannot extend far. Hence, when the ſolvent power becomes weakened by any accident, the overcharge falls not from a height ſufficient for the watery particles to collect into drops, but deſcends in the form of dew.

The action of ſubterraneous fires may, when great enough to warm the air over the ſurface, aſſiſt its ſolvent power; but as this is extremely confined and rare in its appearance, its effect can be but trifling.

We come next to conſider the effect of cold, &c. in impeding the riſe and ſuſpenſion of vapours.

If we attribute the riſe and ſuſpenſion of vapours to the action of the air, as a menſtruum, the power of cold, in impeding the proceſs, appears to be much limited; whereas, if this phænomenon was owing to the immediate action of heat, the abſence of which, or cold, would effectually put a ſtop to it.

The ſolvent power of all fluids is owing to their quality as fluids; and as long as they continue fluid, and are prevented from becoming weaker, they will eternally keep this property of being menſtrua to their proper ſolvends.

A certain degree of heat, neceſſary to keep fluids in their proper form, may poſſibly be required for the producing this phænomenon. But we have no idea of the ſmallneſs of the degree required in this caſe. We know that vapours may be raiſed, and that in great plenty about the bulb of the thermometer, when the mercury is frozen by intenſe cold. May it not be probable, from hence, that the degree of cold, neceſſary to put an intire ſtop to the riſe of vapours, muſt be ſo great as to change the very nature of the air as a fluid; nay, to render it a ſolid maſs?

The degree of cold common to the atmoſphere, has a power of diminiſhing the ſolvent power of all menſtruums; they require more of the ſolvend to ſaturate them when aſſiſted by heat, and, if they be in that ſtate expoſed to cold, they become weakened and over-ſaturated; the over-charge is, of conſequence, ſeparated. Let us apply this to our ſubject.

In cold and froſty winter days, the ſun ſhining clear, we perceive, about noon, large cities, and other moiſt places, when viewed at a diſtance, to be covered with thick and impenetrable miſts. The ſolar heat, by increaſing the action of the air, enables it to ſuſpend a conſiderable quantity of vapour juſt over the ſurfaces of moiſt and damp places, but the coldneſs of the ſeaſon prevents it from being diffuſed to any conſiderable diſtance. The intimate combination of the aqueous and aërial particles does not conſequently take place; hence, the moiſture being only in a ſtate of diffuſion, miſts are formed.

But in a hot ſummer's day, when the ſun is in its meridian height, no ſuch miſts are to be obſerved, though the proceſs of evaporation goes on with increaſed rapidity; the ſolvent power of the air being at ſuch times ſo great as to produce an immediate combination; this being gradually leſſened as the ſun declines, a precipitation enſues, and miſts are formed.

Theſe become more and more perceptible as the ſun declines, and after ſun-ſet grow exceedingly copious and thick, proportionate, *cæteris paribus*, to the heat of the preceding day; hence many tell you, that thick miſts in ſummer nights foretel a hot day.

In many parts of the Eaſt-Indies, eſpecially in places ſituated near the ſea, the heat being altogether inſupportable in the day-time, ſuch a quantity of vapours are taken up, and, conſequently, ſo great an over-charge when the ſolar heat leſſens, that the fogs in the night are ſo thick as to interrupt all kind of commerce among the inhabitants, who are obliged at ſuch times to keep their doors and windows as cloſe as poſſible.

And it has been obſerved in Ruſſia, that in winter, when the north wind blows, the air is rendered too thick for reſpiration; ſuch a plentiful precipitation taking place in conſequence of the cold.

This over-charge, in froſty weather, when falling from a great height, forms ſnow in large flakes; if from that height, which in warmer ſeaſons produces mizzling rains, it becomes ſleet; but when only floating over the ſurface, the watery particles, too ſmall to be viſible, collect upon the ground and leaves of vegetables, and form hoar froſt.

The ſolution of water in air is found to generate cold; this, by weakening the action of the air as a menſtruum, may, in ſome degree, help the precipitation of part of the ſolvend, and be thus a concurring cauſe of the miſts hanging over moſt places in rainy weather.

This diſcovery enables us to account for the diſagreeable chilly coldneſs, which we feel in very damp or wet ſeaſons, eſpecially when ſnow is thawing upon the ground.

The Effect of the different State of the Air, as to Rarity and Denſity, upon its ſolvent Power.

The more denſe the air is, the greater muſt its action be as a menſtruum; for a greater quantity of it being at ſuch times in a given ſpace, more is applied to the ſolvend. The contrary of this muſt happen when its denſity is diminiſhed.

Evaporation goes not on in vacuo, as I have mentioned in a former part of this eſſay.

This is rendered viſible to us by means of the air-pump. For the air being rarefied in the receiver, a dew or miſt is formed in it, and the water is, at length, ſeen trickling down the ſides; the air being thus made leſs capable of ſuſtaining the watery particles, becomes over-ſaturated within; the over-charge is conſequently precipitated.

Does not this experiment ſhew, that the action of heat is only, at the moſt, an aſſiſtant in the formation of vapours, not a neceſſary agent?

Thus thunder-ſtorms, by which the denſity of the air is much diminiſhed, are moſtly followed by ſhowers of rain. And the falling of the mercury in the barometer, prognoſticates a ſimilar precipitation.

The Separation of Water from the Air when combined intimately together.

We know that the air contains, at all times and in every part, a certain quantity of water; and we ſuppoſe a proper mixture, not a mechanical diffuſion, to be the conſequence of this combination.

No method has yet been hit upon to effect this ſeparation. It may perhaps be done by the method uſed in ſeparating other compound bodies, by elective attraction.

But this will be found very difficult, eſpecially in ſuch a manner as that the air, when intirely diveſted of its water, may be rendered capable of examination.

ESSAY IX.

On a new Species of Grain called Siberian or Haliday Barley.

THE ſurface of the earth is cloathed with a variety of graſſes. Such as are intended for the uſe of cattle are ſpontaneous in their growth. Such as are intended for man require culture and attention. The graſſes of the field yield a never-failing verdure. They ſhoot early in the ſpring, and continue to ſend forth radical leaves, which are daily cropped without injuring the plants. Animals ſeldom deſtroy the flowering ſtems. A variety of graſs-ſeeds are conſequently ſown upon our meadows and paſtures by the hand of Providence. This diſlike in animals to brouze upon the ſtraw that bears the ſeed, is particularly favourable to the annual graſſes, and gives an uſeful hint to the intelligent huſbandman not to keep his graſs-lands too long under the ſcythe.

Wheat, oats, barley, and rye are graſſes * for the uſe of man. Theſe vegetables are found in

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* Graſſes are one of the ſeven natural families, into which all vegetables are diſtributed by Linnæus. They are defined to be

in almoſt every climate. Man is a citizen of the world, and indulgent heaven ſupplies him with food wherever he goes. The earth produces a variety of grains. Different countries ſupport ſome kinds more luxuriantly than others. In the northern climates we find plenty of oats and barley. The more ſouthern latitudes are particularly favourable to wheat. Could we look back into the remote annals of time, we ſhould diſcover that few countries were originally bleſſed with the variety of grains and fruits which they at preſent enjoy. Crabs, ſloes, and bramble-berries are the natural fruits of this iſland; and there was a time when wheat was hardly known. Oats, barley, and rye fed the vaſſal and his lord.

In conſequence of a liberal communcation with foreigners, we have daily encreaſed the number of vegetable productions, and have, as it were, naturalized them to our climate. I ſhall

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be plants which have very ſimple leaves, a jointed ſtem, a huſky Calix, termed Gluma, and a ſingle ſeed. This deſcription includes the ſeveral ſorts of corn as well as graſſes. In Tournefort they conſtitute a part of the fifteenth claſs, termed Apetali; and in the Sexual Syſtem of Linnæus they are moſtly contained in the ſecond order of the third claſs, termed Triandria Digynia.

ſhall in this eſſay give an account of a new ſpecies of barley lately brought into this kingdom. As it has been made known to us by the care and attention of Mr. Haliday, I have called it by his name, as an honour due to him. Mr. Haliday, in the moſt correct and circumſtantial manner, communicated his ſentiments upon this new ſpecies, in a letter to my ingenious friend J. B. Bailey, Eſq; of Hope, near Mancheſter, by whom I am favoured with the following extract.

——"On the 25th of May, 1767, I received about a moderate wine-glaſsful of this grain, from a Member of the Society of Arts, &c. at London, with this information, that a foreign nobleman had preſented that Society with about a pint of it, and that it came from Siberia. Not having ſeen Pontoppidan's account of the *Thor-barley*, or *Heaven's corn*, I was doubtful whether it was the product of a cold or warm climate. The amazing extent of Siberia, and the low Latitude of its ſouthern bounds, created this uncertainty. I was from hence induced to divide my ſmall quantity with a neighbouring gentleman, who had in his garden the advantage of glaſſes and fire. But the reſult of his trials ſhewed that it was a native of a cold rather than a warm climate. In the morning of the 26th, I ſowed the other half, in drills, in a ſouth border of my garden, each grain from four to five inches aſunder. The rows were carefully weeded, hoed, and ſometimes watered; but, proving rank, I was obliged to ſupport them with ſtakes and lines. By the latter end of Auguſt ſome few ears were ripened, which I ſnipped off. I continued this practice, morning and evening, until the firſt week in October, and laid the ears by in linen bags.

" In April, 1768, I rubbed out by hand the laſt year's crop, and was happy in finding the quantity was near a quart, equal, if not ſuperior, in quality to the original ſeed. Having prepared all the ſouth borders in the garden, and part of a laſt year's potatoe butt in a field adjoining, I ſowed the whole in drills, as before, in the firſt week in May. The crops were kept clean and hoed. What grew in the garden was ſnipped off as it ripened, and the butt was reaped in the common way on the 28th of Auguſt. The whole was hung up in ſacks until the beginning of April, 1769, when it was thraſhed out, and produced near a buſhel. On the 19th and 20th, having prepared about an acre, of ſeven yards, pretty fine, I drew drills with a plow about ten inches apart, then a ſpace of three feet, and ſo on. The grain was ſown by hand, and the drills were ſmoothed with garden rakes. To keep the corn from falling, though, as it happened, there was no need, large beans were dibbled in the middle of the three-feet ſpaces. In June, the whole was carefully hand-hoed, and on the 14th and 15th of Auguſt was reaped. The calculation I made of the produce from the thraves, proved juſt about 36 buſhels of clean corn.

" Having now got a ſtock, on which I could afford to make experiments of its utility in the grand points of bread and beer, I had two buſhels of 35 quarts, weighing 132 lb. ſent to a country mill. When ground, it yielded 80 lb. of fine flour, equal to London ſeconds, 40 lb. of a coarſer ſort, and about 12 lb. of bran, ſuperior to wheat bran. The beſt flour made excellent bread, ſufficiently light, and ſo retentive of moiſture, as to be as good at twelve or fourteen days after baking, as wheaten bread on the fourth day. But, to give it the faireſt trial, I had 12 lb. of the barley, and 12 lb of wheat flour, equally fine, kneaded with ſome yeaſt, and baked in the ſame oven. The wheaten loaf weighed 15 lb. and the barley 18 lb.

“ Theſe trials ſufficiently eſtabliſhed its excellence as a bread-corn. The foregoing year had proved its fecundity. To find out its quality for ale, I readily accepted the offer made me by a Gentleman of Liverpool, of equal ſkill and attention, and ſent him two buſhels to be malted. He obligingly took the trouble of this ſmall quantity, and made me happy in the account he gave me of its working.

“ In the latter end of January, it was brewed into a half-barrel of ale, and another of ſmall beer. The latter was uſed at a month old, and proved good. The ale was tapt on the 27th of May, and proved of a fine colour, flavour, and body *.

“ You have now all the particulars of my three years experience of this excellent grain.

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* Dr. Lochſter, in his Diſſertation de Medicamentis Norwegiæ, extols the liquor made of it both as palatable and wholeſome. Palmmam, ſays he, quoque reliquis præripit decoctum hordei cœleſtis, vulgo Himmelbyg, grato tam ſapore quam effectu ſe commendans.

If you think the information can be of ſervice to your farming acquaintance, you are at liberty to uſe it as you pleaſe, hoping, however, that my ſucceſs will apologize for my enthuſiaſm in its favour. The idea I entertain of its ſuperior utility to any other ſpring-corn, has induced me to make it as univerſally known as the narrow circle of my acquaintance would permit. I thank you for aſſiſting my views, and am in hopes that Mr. Young will find occaſion to celebrate its virtues from a more ſkilful, though not a more attentive cultivation,

" On the 30th of April, I laid down, in the broadcaſt way, two large acres, of eight yards, with ſix buſhels and a half of this barley, white clover, and hay-ſeeds, and have ſown four other buſhels in a field of poor natural ſoil. Both fields look well. I am alſo happy in knowing that about 20 buſhels of my laſt year's crop are now under ſkilful culture in the ſeveral counties of Kent, Surry, Eſſex, Middleſex, Hereford, Stafford, Cheſter, Derby, York, Durham, and many parts of this County; in two or three counties in Wales, ſix or ſeven in Ireland, and ſome in Scotland; from all which I am filled with the hopes of its ſoon becoming as univerſally eſteemed as known.

Aunfield, June 13, 1770. } W. HALIDAY."

ESSAY X.

On Potatoes.

WHEN firſt the Potatoe was brought into England, it was ſuppoſed to poſſeſs ſome noxious qualities; but the experience of many years has proved it to be a wholeſome and nouriſhing root.

Every kind of plant delights in a particular ſoil. The potatoe thrives beſt in a light loam. Its roots being tuberous, they could not ſwell in a ſtiff clay.

In a former eſſay, I recommended a ſtrict attention to the ſhape of the roots of ſuch plants as were the objects of field-huſbandry. That anatomical inveſtigation will aſſiſt us in the rational cultivation of all kinds of vegetables. The roots of oats are ſtrong and piercing; they are therefore formed by nature to ſeek their paſſage through land but imperfectly tilled, which accounts for the excellent crops of that grain produced upon a ſingle plowing. The roots of wheat and barley are, on the contrary, tender and fibrous: they conſequently require a finer tilth. Beans are tap-rooted. Aſſiſted by their wedge-like form, they pierce through the tougheſt ſoils.

I need not run through all the plants of the field, to prove that each has a choice of ſoil. In this the animal and vegetable worlds perfectly agree, and a ſmall degree of reflection will enable us to trace the affinity.

The potatoe may be conſidered as a certain relief to the poor againſt a deficiency of the corn harveſt: for that reaſon it requires our moſt ſerious attention. Various are the methods recommended for its cultivation. Practical books of huſbandry circumſtantially relate them. I therefore judge a regular detail unneceſſary in this place.

As this moſt uſeful root delights in a looſe ſoil and a great deal of ſun, we ſhould anxiouſly endeavour to obtain theſe ends in all the modes of cultivation. When raiſed in hillocks the earth lies light upon the ſpreading roots, and the ſun has free acceſs to the crown of the hills by the falling down of the haulm into the ſurrounding trench. By the frequent earthings that are required in this manner of culture, the ſoil is kept clear of weeds, and the whole field is reduced into the form of a garden. This is a very profitable method of cultivation, and the expence attending it is not ſo conſiderable as might at firſt be imagined. Two men and a boy will plant an acre in four days, the expence of which muſt be eſtimated according to the rate of labour in the country. Two men will give the ſecond and laſt earthing in three days. I uſually place the hills in the quincunx form, meaſuring four feet from center to center. Into each hill I put five cuttings, placing one in the middle, and the others round it. Excellent crops may be obtained by putting one large potatoe into the center of each hill. When the land is freſh, and the buſineſs has been well attended to, the cultivator may expect near a peck of potatoes in each hillock; which is a larger produce than can be obtained by any other method.

It will here be neceſſary to obſerve, that the ſpade, where hands can be procured, is greatly preferable to the plow; but, in countries where they are ſcarce, the plow is a good inſtrument, provided the farmer takes care to allow a ſufficient diſtance between the rows, in order to deſtroy the weeds, and throw freſh mould up to the plants. This diſtance ſhould not be leſs than three feet, eſpecially in ſhallow ſoils.

It is cuſtomary to put the manure over the ſets, but the practice is injudicious. By attending to the manner that the potatoe grows above and below ground, we may be enabled to form very correct rules of cultivation.

As ſoon as the potatoe puts forth its ſtalk, in order to riſe to the ſurface, it ſends out ſeveral ſtrong roots which run obliquely downward, and may be called the feeding roots. They do not produce fruit. When the manure is placed under the ſets, the feeders pierce into it, and extract the oily and mucilaginous particles. The potatoe creeps under-ground, and, in proportion to the covering of earth, the ſtalk within the ground becomes longer or ſhorter. From this ſtalk lateral ſhoots are detached, which are bearers. Theſe bearers are, in fact, branches within-ground. They go off from the deſcending ſtalk in the ſame manner and diſtance as the branches do from the aſcending one. Had they appeared upon the ſurface, they would have brought forth leaves, flowers, and apples, but being confined they produce potatoes.

In the ſixth eſſay I have demonſtrated that all the parts of a plant are the ſame; the only difference lies in the ſhape. Trees may be planted with their roots in the air, and their branches in the earth. In that ſtate they will live and grow. A fibrous root that has eſcaped through the earth, becomes a tree perfect in all its parts. The tops of potatoes, cut off in June and planted in the earth, will take root, and produce a good crop.—I have obſerved that the bearing ſhoots go off from the main root in the manner of the branches from the main ſtem; conſequently, we are directed to lengthen the main root, in order to increaſe the number of bearing ſhoots. This is accompliſhed by giving frequent earthings to the plant. That operation, however, requires diſcretion. For when too great a load of earth has been thrown up, the loweſt ſhoots being deprived of the ſun and air, either become barren, or produce ſmall and decayed fruit. Potatoes planted in drills are not ſubject to this inconvenience. In general they have too ſlight a covering of earth, ſo that they ſeldom put out above one layer of bearing ſhoots. There is another objection to this method: for unleſs the bearers run in the direction of the drills, they eſcape at the ſides, and aſcend in a ſtalk, which bears leaves and flowers inſtead of potatoes. The haulm alſo of one row falls upon the crown of the contiguous one, which, by keeping out the ſun, diminiſhes the crop. When cultivated in hillocks, the haulm falls down into the trench, leaving the crowns expoſed to the ſolar heat. The potatoe delights in the ſun, and cannot bear the ſhade; for which reaſon we ſhould be careful, in all the modes of cultivation, to preſerve this bias of nature.

In ſome places it is uſual to dibble in the ſets at ſixteen inches diſtance. This is an excellent method. The land requires a good dreſſing of rotten dung, and muſt have deep ſtirrings with the plow, if the ſtaple of the ſoil will admit of it.

Soon after the appearance of the plants, the intervals ſhould be carefully hand-hoed, which operation muſt be repeated occaſionally. Some people trench with the ſpade, placing long litter at the bottom of the trenches; after which the ſets are dibbled in. This is a good, but expenſive method. It is agreeable to the nature of the plant, as it encourages the running of the bearing ſhoots.

In whatever manner potatoes are cultivated, unleſs upon freſh land, dung muſt be uſed. It is an error to ſay that they do not exhauſt the ſoil. On the contrary, they impoveriſh greatly; againſt which there is no remedy but plenty of dung and clean huſbandry. Under theſe circumſtances they may be conſidered as an ameliorating crop.

In very coarſe clays I have raiſed large crops of this root in hillocks, where it would have been impoſſible to have cultivated them in drills. The reaſon is obvious.

Of potatoes there are various kinds, and we are every day adding to their number by the induſtry of ſuch gardeners as raiſe them from ſeed. I ſhall only remark, that the ſorts which yield the greateſt increaſe are the moſt proper for the farmer. The early and tender kinds come more immediately under the care of the gardener.

In this general view, the Reader will obſerve, that I do not conſider the potatoe itſelf as the root of the plant, but rather as an under-ground fruit, produced upon a confined branch. The real roots do not produce potatoes; they only ſerve the purpoſes of drawing nutriment from the ſoil, in the ſame manner that the leaves above extract it from the atmoſphere. The potatoe below and the apple above are, in fact, the ſame; but, living in different elements, they aſſume different appearances. The one ſeems to have been intended for the preſervation of the ſpecies, the other for the food of animals.

ESSAY XI.

On the Culture of Turnips.

THE drill method of raiſing turnips is generally practiſed by ſuch Gentlemen as wiſh to be conſidered in the light of correct huſbandmen. The broadcaſt, or old method, is however better adapted to the generality of farmers. The inſtruments uſed are plain and ſimple in their ſtructure, eaſy and familiar in their application. The drill ſyſtem requires complicated machinery, and, being founded upon principles, demands a degree of reaſoning to underſtand it. After which, the practice requires a ſpirited kind of attention not to be met with in every village.

I do not propoſe to give a comparative view of the two methods. My intention in this eſſay is only to throw a general light upon the drill culture of turnips, and to point out to the plain farmer an eaſy and certain method of raiſing a large crop upon almoſt any ſoil.

The land being well plowed and harrowed, but not manured, furrows muſt be drawn all over the field with the common plow, at three feet diſtance. Theſe open furrows muſt nearly be filled with rotten dung. This operation is conducted by women and children, as uſual in ſetting potatoes. After this the earth muſt be returned into the furrow by a light plow drawn by one horſe. The whole field being now diſpoſed in ridges at three feet diſtance, the ſeed muſt be ſprained upon them from the fingers; after which a buſh-harrrow muſt be brought in to cover the ſeed, or a perſon with a rake may follow the ſeedſman. For the purpoſe of ſowing the ſeed, I always make uſe of the hand-drill deſcribed by Mr. Young in the firſt volume of his Northern Tour. It is a cheap inſtrument, and does the work with expedition and certainty. In drilling of turnips the farmer ſhould be adviſed not to be ſparing of ſeed; for, as the rows undergo the operation of the hand-hoe, there can be no danger from a ſuperfluity of plants.

As ſoon as the turnips have got into the rough leaf they muſt be thinned by the hand-hoe, which operation may be performed by common ſervants. Broadcaſt turnips, on the contrary, require the utmoſt dexterity. This I eſteem a material advantage.

When the weeds come up in the intervals, they muſt be turned down by plowing a furrow from the turnips, which will leave an arch of earth between the rows. At a proper ſeaſon, when the weeds advance, this arch muſt be ſplit, ſo that the turnips will be left upon ridges, with a trench in the place of the former arch. The rows ſhould undergo a ſecond hoeing; and if any double turnips are left, they muſt be removed by the hand. Women and children perform this operation with great expedition.

It is impoſſible to conceive a finer ſight than a field of turnips dreſſed in this manner. The expence appears to be great; but the ſuperior excellence of the crop, added to the cleanneſs of the land, will much more than over-balance the additional expence and trouble. I do not take upon me to eſtimate the expence of this method of culture, as it depends greatly upon the addreſs of the perſons employed; on which account the ſecond year will be leſs expenſive than the firſt. I do not mean to confine the farmer to a ſervile obedience to the rules that I have laid down. If he only obſerves the general principle of laying the manure at the bottom of the furrows, he may reduce every other part of the operation to his own ſentiment.

Mr. Benſon, an excellent farmer and ingenious mechanic, who lives in the neighbourhood of Ripon, is the perſon that contrived the above mode of cultivation, and has followed it himſelf for many years, with great ſucceſs. His method varies in ſome particulars from what I have deſcribed. He drills the ſeed upon the dung, and draws the earth over it with a kind of harrow without teeth. It is ſomething of the ſhape of a crooked elbow. I believe this method is better than what I have deſcribed, eſpecially in ſultry weather. The ſeed, when placed upon the moiſt dung, and covered with the earth, ſoon vegetates, and puſhes upwards with ſurprizing vigour. The plants being ſtrong, ſoon get into rough leaf, and by that means eſcape the ravages of the fly. I once ſowed an acre of turnips in this manner during a ſultry ſeaſon. The plants were up on the ſeventh day, while the broadcaſt part of the ſame field did not ſhew the leaſt appearance till the fourteenth day after ſowing. The field was ſown at the ſame time, and the only difference lay in the culture. In hot and ſultry weather the manure, as commonly uſed, is expoſed to the ſcorching rays of the ſun; great part of it is conſequently exhaled. But when confined in the furrows the exhalation from it is abſorbed by the earth, and retained.

It may here be obſerved, that the above method does not eſſentially differ from the drill and horſe-hoeing culture, excepting in the diſtribution of the manure.

The horſe-hoeing method begins to gain ground in this country. It is far ſuperior to the broadcaſt, eſpecially in diſtricts where expert hoers cannot be procured.

An ingenious friend of mine now raiſes excellent crops of turnips by the help of the drill and horſe-hoe, where that uſeful vegetable is ſcarcely known. What few are raiſed in his neighbourhood are ſo over-run with weeds for want of hand-hoeing, that the crop becomes deſtructive both to the landlord and tenant. He has been ſo obliging as to communicate to me his ſentiments upon this head, which, I dare ſay, will be uſeful to ſuch farmers as are deſirous of raiſing large and clean crops of turnips at a ſmall expence.

This ingenious cultivator brings the land deſtined for turnips into excellent tilth by frequent plowings. At the laſt ſtirring, which is about Midſummer, either a little before or after, according to the ſeaſon, he harrows the land very fine, and, with the hand-drill deſcribed in the firſt volume of Mr. Young's Northern Tour, ſows the ſeed in rows at two feet and a half diſtance. After this the land is harrowed once over with light harrows, in order to cover the ſeed. When the turnips are up and pretty ſtrong, they are ſet out at about a foot diſtance with the hand-hoe. When the land is much infeſted with weeds, he plows two furrows from the rows to the center of the intermediate ſpace; and when the weeds make a ſecond ſhoot, he ſplits the ridge with a horſe-hoe with a double mould-board. When the land is not very foul, the latter operation is ſufficient without the former. In this manner a large and clean crop of turnips may be procured with very little aſſiſtance from the hand-hoe.

In countries where hands are ſcarce, this is an excellent and judicious method. Every perſon may introduce ſuch variations as may ſuit his own convenience, provided he takes care to preſerve the general principle.

I have known a large field of broad-caſt turnips very well hoed, by cutting them into ſtripes with a light plow, and afterwards hand-hoeing the ſtripes by common labourers. This method is no deſpicable one in countries where hands are ſcarce. Women and children, at a ſmall expence, may afterwards be ſent into the field to draw the double turnips, and ſet out the whole in a correct manner.

ESSAY XII.

On the Culture of Carrots, and their Uſe in fattening of Hogs.

IN the Year 1769, I took two acres of rich ſand land, which the year before had been plowed out of ſwarth, and had borne a crop of very fine cabbages. About the 27th of March I plowed and cleared the land from the cabbage ſtalks, and graſs that had grown between the rows, and prepared it without putting any manure upon it, for ſowing my carrots in the following manner. A plow with two horſes drew a furrow of the common depth, and was followed by another plow with two horſes in the ſame furrow, which turned up the ſoil ten or twelve inches deep. This is called double plowing. Two plows will do about an acre a day. On the 5th of April I ſowed the ſeed, about four pounds to an acre. My gardener finiſhed the two acres with eaſe in a day, having mixed the ſeed with about a buſhel of dry ſand. The ſeed was immediately harrowed in. When the carrots were about a month old, I ſent ſome women into the field to hoe them. The hoes were only three inches broad. I afterwards had the field weeded twice by the hand, which, although very expenſive, I found to be infinitely the beſt way. The crop when taken up weighed twenty tons without the tops. I ſhall now proceed to the expence of cultivating theſe two acres of carrots.

	l.	*s.*	*d.*
Rent, - - - - - - - - -	3	0	0
Taxes, - - - - -	0	4	0
Two days plowing with two plows,	0	14	0
Three days harrowing, - -	0	9	0
Cleaning the ground from the cabbage ſtalks, &c.	0	6	0
Eight pounds of ſeed, - -	0	12	0
A man one day ſowing, - -	0	1	6
Hoeing, - - - -	0	15	0
Hand-weeding, firſt time, - -	1	0	0
* Ditto, ſecond time, - -	1	11	6
	£. 8	13	0

Mr. Young, in his treatiſe upon the management of hogs, is of opinion that boiled carrots are the beſt food for fattening that uſeful animal. He prefers them to pollard, white peaſe, buck-wheat, or potatoes. I beg leave to tranſcribe the experiment upon which he founds his opinion.

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* The reaſon why the ſecoud weeding coſt more than the firſt, was becauſe the women had ſixpence per day, it being hay-time, whereas the firſt time they had only fourpence.

" In January, 1766, I drew from the herd ten hogs, as equal in ſize as poſſible, and weighed them alive in five lots.

		S.	P.
Nº 1.	weighed	13	4
2.	———	12	6
3.	———	13	0
4.	———	12	11
5.	———	13	1

" A nearer equality than this, in matters that can neither be added to nor diminiſhed, can ſcarcely be expected.

" N° 1. was fatted with white peaſe, that weighed ſixty-ſix pounds per buſhel, the price 30 s. per quarter.

" N° 2. with pollard, that weighed twenty-two pounds per buſhel, the price 9 d. per buſhel.

“ N° 3. with buck-wheat, that weighed forty-ſeven pounds per buſhel, the price 2 s. 3 d. per buſhel.

“ N° 4. with boiled potatoes, that weighed fifty-four pounds per buſhel, the price 2 s. per buſhel.

“ N° 5. with boiled carrots, that weighed raw fifty-five pounds per buſhel, the price 1 s. 1 d. per buſhel.

“ I thought it beſt to fix on a given ſum, as proper to fat each hog. The people I conſulted were of opinion, that eight buſhels of white peaſe were neceſſary to fat one ſuch hog well. This I accordingly fixed on as my criterion. The account of the expence therefore ſtood thus:

					l.	*s.*	*d.*
N° 1.	Peaſe, 16 buſhels, -				3	0	0
2.	Pollard, 80 buſhels, -				3	0	0
3.	Buck-wheat, 27 buſhels, -				3	0	9
4.	Potatoes, 28 buſhels,	2	16				
	Labour and coals, -		4				
					3	0	0
5.	Carrots, 49 buſhels,	2	13	2			
	Labour and Coals,		6	10			
					3	0	0

" Each lot was weighed as ſoon as the food was done. The reſult was as follows:

		S.	P.
N° 1.	weighed	27	6
2.	———	27	9
3.	———	29	13
4.	———	25	7
5.	———	31	0

" It is evident from this experiment, that carrots boiled are ſuperior to any other food. I did not expect that potatoes would be ſo much inferior; but I have found from divers other trials ſince, that it is requiſite to mix the meal of ſome kind of corn with them. Pollard in this trial, as in the laſt, is ſuperior to peaſe."

From this experiment of Mr. Young, the boiled carrots appear in a favourable light. I was therefore induced to follow his advice, and accordingly bought in twelve hogs as follows:

		S.	P.
N° 1.	———	15	2
2.	———	16	0
3.	———	14	12
4.	———	13	13
	Carried over	59	13

N° 5.

		S.	P.
	Brought over	59	13
N° 5.	———	12	6
6.	———	17	2
7.	———	14	10
8.	———	13	3
9.	———	16	10
10.	———	17	0
11.	———	12	10
12.	———	13	6
		177	4

On the 26th of October, 1769, I put them up to feed upon boiled carrots, which they eat with ſeeming pleaſure. On the 28th of December I weighed them again, being fat, and found that they had gained, in the nine weeks, juſt 33 ſt. 10 lb. During that period they conſumed 574 buſhels of carrots, at 4 ſt. per buſhel.

	l.	*s.*	*d.*
Theſe 574 buſhels, if eſtimated at 1 s. 1 d. per buſhel, would have coſt	34	13	10
Attendance, fire, &c. for nine weeks,	3	12	0
	£. 38.	5	10

A farmer preſuming upon Mr. Young's experiment, and purchaſing carrots at 1 s. 1 d. per buſhel, would juſt give 38 l. 5 s. 10 d. for 33 ſt. 10 lb. of live fleſh.

Thus far I have related my experiment, and ſo far it accompanies Mr. Young's. The difference in the reſult is amazing. Mr. Young gets 17 ſt. 13 lb. of live fleſh for 3 l. I pay 38 l. 5 s. 10 d. for 33 ſt. 10 lb. which is upwards of 23 s. per ſtone.

It will be unneceſſary to make many reflections upon the reſult of this intereſting experiment. I ſhall only obſerve, that every thing relative to it was conducted with that care and attention which trials of this important nature require. Towards the latter end of fattening, I found it neceſſary to beſtow upon the hogs as much bean meal as coſt me 6 l. without which the bacon would not have been marketable.

Willing to carry my trial as far as it could be proſecuted, I killed the hogs. When dried, they weighed, without the cheeks, 104 ſt. which ſold in the London market for 40 s. a hundred. The cheeks were valued at half a crown a piece. In the courſe of drying, the bacon loſt upwards of 70 ſt. which great conſumption was, in ſome degree, made up by the excellence of its quality.

	l.	*s.*	*d.*	*l.*	*s.*	*d.*
Prime coſt of 12 hogs,	22	9	0	32	1	0
Bean meal,	6	0	0			
Fire and attendance for nine weeks,	3	12	0			
Value of the bacon and cheeks,				27	10	0
Loſs				£. 4	11	0

From the above experiment it is plain, that we ſhould not depend upon carrots *alone* for fattening of hogs. A judicious *mixture* of food conſtitutes the moſt rational and profitable method. Mr. Young makes his carrots worth 13d. a buſhel in fattening. I loſe upwards of 4l. beſides 574 buſhels of carrots, which I could have ſold for 28l. It may be proper to obſerve, that my hogs, being much larger than Mr. Young's, eat a proportionable quantity of carrots before they were fat. This difference in ſize may probably account, in ſome degree, for the different reſults of our experiments.

ESSAY XIII.

On the Study of Nature.

THE ſtudy of nature is one of the moſt pleaſing amuſements that can engage the mind of man. The entertainment that it gives, is as infinite as the variety of the ſubjects of which it is compoſed. When we conſider the hiſtory of nature as interwoven with religion, our breaſt is immediately opened, and the divine goodneſs ſinks down into the heart with energy and conviction. Akenſide beautifully expreſſes himſelf when he ſays,

——— the men
Whom nature's works can charm, with God himſelf
Hold converſe; grow familiar, day by day,
With his conceptions; act upon his plan,
And form to his, the reliſh of their ſouls.

Wherever we caſt our eyes a field of contemplation opens to our view. The animal, vegetable, and mineral worlds teem with matter for the exerciſe of our minds.

Man, in a ſtate of nature, is obliged to his induſtry for meat and cloathing. He is born naked and defenceleſs. Early he leaves the foſtering hands of his parents, and goes into the wide world, where his underſtanding muſt ſupply the wants of nature. Being a ſocial animal, he herds with his fellow-creatures. Societies are formed for mutual protection. Providence having beſtowed upon man, from the beginning, all manner of power over the beaſts of the field, the fowls of the air, and the fiſhes of the ſea, he executes his power, and ſubjects them to his will. The vegetable creation lies open to his view. Minerals, though hid in the bowels of the earth, yield to his induſtry. For him all things ſeem to have been made. Every thing ultimately reſolves itſelf into the eaſe, comfort, and ſatisfaction of man. Whether we conſider them as ſupplying his natural wants, or contributing to his artificial deſires, the argument is ſtill the ſame. He is lord of all, and enjoys the whole.

Over ſome animals he is forced to exerciſe command. Others follow him, and cannot exiſt without his protection. Sheep that ſupply him with food and cloathing, ſtand moſt in need of his aſſiſtance. They lodge, as it were, in his boſom—and are never found in countries untrod by man.

The face of the globe is covered with a laſting verdure for the uſe of animals that are friendly to man. In every country, and in every place, the bountiful earth brings forth its fruits in due ſeaſon, and rewards the induſtrious care of the huſbandman. Corn is ſpontaneous in no climate, but the induſtry of man can raiſe it in all.

The juſt contemplation of the works of Providence is the humble adoration of a Chriſtian. He views, with gratitude, the good things that God has made, and enjoys them chearfully. Let the melancholy Recluſe ſhrink into his wretched habitation, and, with himſelf, bury the gloomy horrors of his mind. God delights in the chearful contemplation of his works. The Saviour of the world bids us *conſider the lilies of the field how they grow; they toil not, neither do they ſpin; and yet Solomon in all his glory was not arrayed like one of theſe.*

The regular return of ſeaſons, and the invariable order that vegetables obſerve in budding, leafing, and flowering, beſpeak almighty wiſdom and almighty power. A mind harmonized to ſuch divine contemplations, ſees at all times, and feels with warmth the goodneſs of the Creator to the created. He conſiders the works of nature as the ſilent, but expreſſive, language of the Deity; and while he ſeems only to admire, is wrapt in gratitude and devotion.

ESSAY XIV.

On the Time of Sowing.

MR. Harold Barck, in his ingenious diſſertation upon the foliation of trees, publiſhed in the Amæn. Acad. Vol. III. informs us, that the illuſtrious Linnæus had, in the moſt earneſt manner, exhorted his countrymen to obſerve, with all care and diligence, at what time each tree expands its buds and unfolds its leaves; imagining, and not without reaſon, that his country would, ſome time or other, reap ſome new and perhaps unexpected benefit from obſervations of this kind made in different places.

As one of the apparent advantages, he adviſes the prudent huſbandman to watch, with the greateſt care, the proper time for ſowing;

becauſe this, with the divine aſſiſtance, produces plenty of proviſion, and lays the foundation of the public welfare of the ſtate, and of the private happineſs of the people. The ignorant farmer, tenacious of the ways and cuſtoms of his anceſtors, fixes his ſowing ſeaſon generally to a month, and ſometimes to a particular day, without conſidering whether the earth be in a proper ſtate to receive the ſeed; from whence it frequently happens that what the ſower ſowed with ſweat, the reaper reaps with ſorrow. The wiſe œconomiſt ſhould therefore endeavour to fix upon certain ſigns whereby to judge of the proper time for ſowing. We ſee trees open their buds and expand their leaves, from whence we conclude that ſpring approaches, and experience ſupports us in the concluſion; but no body has as yet been able to ſhew us what trees providence has intended ſhould be our kalendar, ſo that we might know on what day the countryman ought to ſow his grain. No one can deny but that the ſame power which brings forth the leaves of trees, will alſo make the grain vegetate; nor can any one aſſert that a premature ſowing will always, and in every place, accelerate a ripe harveſt. Perhaps therefore we cannot promiſe ourſelves a happy ſucceſs by any means ſo likely, as by taking our rule for ſowing from the leafing of trees. We muſt for that end obſerve in what order every tree puts forth its leaves according to its ſpecies, the heat of the atmoſphere, and the quality of the ſoil. Afterwards, by comparing together the obſervations of the ſeveral years, it will not be difficult to determine, from the foliation of the trees, if not certainly, at leaſt probably, the time when annual plants ought to be ſown. It will be neceſſary likewiſe to remark what ſowings made in different parts of the ſpring produce the beſt crops, in order that, by comparing theſe with the leafing of trees, it may appear which is the moſt proper time for ſowing.

To theſe moſt ingenious remarks, Mr. Barck has added the order of the leafing of trees in Sweden. Mr. Stillingfleet is the only perſon that has made correct obſervations upon the foliation of the trees and ſhrubs of this kingdom. The following is his kalendar, which was made in Norfolk in the year 1765.

1	Honey-ſuckle	Jan.	15
2	Gooſeberry	March	11
3	Currant		11
4	Elder		11
5	Birch	April	1
6	Weeping Willow		1

7	Raſpberry	April	3
8	Bramble		3
9	Briar		4
10	Plumb		6
11	Apricot		6
12	Peach		6
13	Filberd		7
14	Sallow		7
15	Alder		7
16	Sycamore		9
17	Elm		10
18	Quince		10
19	Marſh Elder		11
20	Wych Elm		12
21	Quicken Tree		13
22	Hornbeam		13
23	Apple Tree		14
24	Abele		16
25	Cheſnut		16
26	Willow		17
27	Oak		18
28	Lime		18
29	Maple		19
30	Walnut		21
31	Plane		21
32	Black Poplar		21
33	Beech		21
34	Acaſia Robinia		21

35 Aſh

35	Aſh - - - - - - -	April 22
36	Carolina Poplar - - - - - -	22

In different years, and in different ſoils and expoſitions, theſe trees and ſhrubs vary as to their leafing; but they are invariable as to their ſucceſſion, being bound down to it by nature herſelf. A farmer, therefore, who would uſe this ſublime idea of Linnæus, ſhould diligently mark the time of budding, leafing, and flowering of different plants. He ſhould alſo put down the days on which his reſpective grains were ſown; and, by comparing theſe two tables for a number of years, he will be enabled to form an exact kalendar for his ſpring corn. An attention to the diſcolouring and falling of the leaves of plants, will aſſiſt him in ſowing his winter grain, and teach him how to gueſs at the approach of winter. Towards the end of September, which is the beſt ſeaſon for ſowing wheat, he will find

The leaves of the plane tree, tawney;
——— of the oak, yellowiſh green;
——— of the haſſel, yellow;
——— of the ſycamore, dirty brown;
——— of the maple, pale yellow;
——— of the aſh, fine lemon;

The leaves of the elm, orange;
——— of the hawthorn, tawney yellow;
——— of the cherry, red;
——— of the hornbeam, bright yellow.

There is a certain kind of genial warmth which the earth ſhould enjoy at the time the ſeed is ſown *. In the animal world we obſerve this in the moſt convincing manner. In brutes the ſymptoms of that period are plainly marked. The budding, leafing, and flowering of plants, ſeem to indicate the ſame happy temperature of the earth.

Appearances of this ſublime nature may be compared to the writing upon the wall, which was ſeen by many, but underſtood by few. They ſeem to conſtitute a kind of harmonious intercourſe between God and man. They are the ſilent language of the Deity.

The

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* In the North of England, when the earth turns up with a mellow and crumbly appearance, and ſmoaks, the farmers ſay the earth is *brimming*. This ſtate is but of ſhort duration, and ſhews the exact time when the ſeed ſhould be ſown. This appearance will ever coincide with the budding, leafing, flowering, &c. of ſome plants that grow in the field. The huſbandman ſhould therefore, at that time, make his obſervations, in order to form his kalendar of Flora.

The ingenious and indefatigable Mr. Young has endeavoured to aſcertain the time of ſowing by another method. His experiments are accurately conducted, and his concluſions from them fairly drawn; but it were to be wiſhed that he had interwoven the idea of Linnæus with his own experiments; we ſhould then have had an unerring rule to go by. The temperature of the ſeaſon, with reſpect to heat and cold, drought and wet, differs in every year. Experiments made this year cannot determine, with certainty, for the next. They may aſſiſt, but cannot be concluſive. The hints of Linnæus conſtitute an univerſal rule for the whole world, becauſe trees, ſhrubs, and herbs, bud, leaf, flower, and ſhed their leaves, in every country, according to the difference of ſeaſons.

In order to induce ſome careful obſerver to proſecute this uſeful inquiry, I ſhall ſelect ſome of Mr. Young's experiments, as an excellent pattern to go by; and I flatter myſelf that the obſervations in the former part of this eſſay, will be ſufficient to direct him in combining the experiments of the field with the ſublime ideas of the philoſopher.——The experiments I refer to are recorded in the firſt volume of Experimental Agriculture, under the article Wheat.

“ EXPERIMENT V. p. 293.

“ In 1765, I marked ſeveral drills, each a perch long, in a piece of fallow. The ſoil a looſe woodcock loam on the ſurface, and under that a clay. Sowed each with an ounce of wheat, at the following times:

N° 1.	Auguſt	18
2.	——	31
3.	September	10
4.	——	17
5.	——	24
	Plowed again.	
6.	October	1
7.	——	13
8.	——	20
	Another plowing.	
9.	——	31
10.	November	9
11.	——	16
	Another plowing.	
12.	——	23
13.	December	3
14.	——	13

“ The drills in all the experiments were two feet aſunder. They were all hand-hoed at the ſame time.

The produce.

N° 1.	6½ ounces
2.	6 1
3.	6^2
4.	6_4
5.	6¼
6.	6½
7.	5½
8.	5¼
9.	5
10.	5
11.	5¼
12.	4¾
13.	3½
14.	3

“ This experiment, though not deciſive in every point, is very important in the reſult of late ſowing. October is, in Suffolk, ſuppoſed to be the beſt time for wheat-ſeed ſowing: but this ſhews that September is at leaſt equal, if not ſuperior: and, what would aſtoniſh one half of the farmers in the country, is, that the latter part of Auguſt is as good as either; but after October the product decreaſes; and in December it comes to a trifle. This effect is particular, as the latter-ſown corn had the advantage of three plowings more than the early.

“ Ex-

“ EXPERIMENT VI. p. 294.

“ In 1765, marked ſome perches of fallow in the ſame field, and ſowed them each with one ounce of ſeed, at the following times:

N° 1.	Auguſt	23
2.	———	31
3.	September	3
	Plowed again.	
4.	———	16
5.	September	21
6.	———	28
	Another plowing.	
7.	October	7
8.	———	16
9.	———	26
	Another plowing.	
10.	November	4
11.	———	14
12.	———	20
13.	———	28
	Another plowing.	
14.	December	6
15.	———	12
16.	———	18

“ Hoeing, cleaning, &c. performed on the ſame days.

The produce.

N° 1.	5½ ounces.
2.	5¾
3.	7¼
4.	6½
5.	6¼
6.	6
7.	6¼
8.	6
9.	5½
10.	5¼
11.	5
12.	4¾
13.	5
14.	4½
15.	4½
16.	4¼

" This experiment, like the laſt, appears to me to have an important reſult. So early as Auguſt, ſeems to be ſomewhat improper for ſowing: from the beginning of September to the middle of October, the moſt advantageous ſeaſon: November bad, but December worſe; and this degradation, notwithſtanding the progreſſion of plowing, which is a material point, and by no means to be overlooked.

" Ex-

“ Experiment VII. p. 295.

“ In 1765, marked ſome perches of fallow in a field conſiſting of a light gravelly loam, and ſowed them each with one ounce of ſeed, at the following ſeaſons :

N° 1.	Auguſt	23
2.	September	3
3.	———	10
	Freſh plowed.	
4.	———	21
5.	———	28
6.	October	4
7.	———	11
8.	———	18
	Another plowing.	
9.	———	25
10.	November	2
11.	———	9
	Another plowing.	
12.	———	16
13.	———	23
14.	———	30
	Another plowing.	
15.	December	7
16.	———	18
17.	———	26

The produce.

N° 1.	4½ ounces
2.	5½
3.	7
4.	7¼
5.	7½
6.	7½
7.	7¼
8.	7½
9.	6¼
10.	6¾
11.	6¼
12.	6
13.	5½
14.	5
15.	4½
16.	4
17.	4

“ We find in this table, that the principal produce is from N° 3 to 8, that is, from the 10th of September to the 18th of October; before and after which time we do not find any date with ſo conſiderable a one. The ſimilarity of the produce of the dates, within that period, gives much reaſon to ſuppoſe an equality from the beginning to the end of it. Number of plowings are apparently of no effect in making up for too late a ſowing: but whether that is really the caſe, cannot be abſolutely known, as the product might otherwiſe have been leſs.

" Experiment VIII. p. 296.

" In 1765, marked ſome perches in the ſame field, on a clover lay that had been mown once, and part twice; the plowings did not vary in this experiment. They were ſown in the following ſeaſons:

N° 1.	Auguſt	17
2.	———	26
3.	September	3
4.	———	10
5.	———	21
6.	———	28
7.	October	11
8.	———	18
9.	———	25
10.	November	2
11.	———	9
12.	———	16
13.	———	23
14.	———	30
15.	December	7
16.	———	18
17.	———	26

“ Thoſe numbers that were ſown before the ſecond crop of clover had come to a proper height for hay, were mown young, and the produce carried off. The hoeing and weeding were performed the ſame days to all.

The produce.

N° 1.	3¼ ounces.
2.	3¾
3.	5
4.	7
5.	8½
6.	7½
7.	7
8.	7
9.	7
10.	6½
11.	6¼
12.	6½
13.	5½
14.	5½
15.	4½
16.	5
17.	4¾

“ This experiment, upon the whole, confirms the reſult of the preceding; which is of the more conſequence, as it is a total variation, being a clover-land crop, and all the reſt fallow ones. But the trifling product of the firſt numbers ſown early, ſhews that very early ſowing is vaſtly worſe on clover than on fallow land; which, I ſuppoſe, is owing to the roots of the clover not only being ſhort of their proper ſize and growth, but alſo in an improper ſtate for forwarding the growth of the wheat; perhaps ſo full of juices as to mould the ſeed.

" Experiment IX. p. 297.

" In 1766, I marked ſeveral perches of fallow land, in the field of experiment V. and ſowed them each with one ounce of ſeed as before, at the following ſeaſons:

N° 1.	July	30	
2.	Auguſt	4	
3.	———	11	
4.	———	18	
A freſh plowing.			
5.	———	25	
6.	September	1	
7.	———	8;	heavy rain.
Another plowing.			
8.	———	15	
9.	———	22	
10.	———	29	

Another plowing.
N° 11. October 7
12. ——— 13
13. ——— 20
14. ——— 27
Another plowing.
15. November 3
16. ——— 13; heavy rain fell the 8th.
17. ——— 17
18. ——— 24
Another plowing.
19. December 1
20. ——— 8
21. ——— 15
22. ——— 22
23. ——— 29
24. January 29; the ſeverity of the weather prevented ſowing ſooner.
25. February 7
Another plowing.
26. ——— 14
27. ——— 21
28. ——— 28
29. March 7
30. ——— 14
Another plowing.
31. ——— 28

N° 32. April 6
33. ——— 13
34. ——— 23
Another plowing.
35. ——— 28

"I ſhould here remark, that the plowings were never performed when the ground was in an improper ſtate for the operation for a wheat ſowing; reſpecting wet, I mean. The hoeing and weeding were performed on the ſame days to all, except the ſpring ſowings, which varied once.

The produce.

N° 1 ——— 3 ounces.
2 ——— 3½
3 ——— 3½
4 ——— 5
5 ——— 5½
6 ——— 7½
7 ——— 8
8 ——— 7¼
9 ——— 8
10 ——— 7½
11 ——— 7½
12 ——— 6¾
13 ——— 7
14 ——— 6½

N° 15	6½ ounces.
16	6½
17	6¼
18	6
19	5½
20	4¼
21	5
22	4½
23	4
24	3½
25	3½
26	3
27	3¼
28	3
29	3
30	3½
31	3¾
32	3½
33	3
34	2½
35	3

“ The reſult of this trial, I apprehend, is very important: the ſeaſons, from firſt to laſt, are ſo extreamly various, that the effect might eaſily be ſuppoſed to carry concluſions of conſequence. The end of July, and the firſt fortnight in Auguſt, are evidently very improper ſeaſons; the laſt fortnight better. From the 1ſt of September to the 20th of October, the prime ſeaſon of the whole experiment: from the 27th of October to the 24th of November, the produce is not greatly inferior. The December ſowings are much lower. Thoſe of January, and all after, very low; not much difference between them. Now, it muſt be conſidered, that there are eight plowings between the firſt and the laſt ſown, and yet the produce of each is the ſame; and it is obſervable, that there appears much reaſon to think, that the plowings have little, if any effect. The ſeaſon appears to be the cauſe alone of variation: a point of great conſequence for every farmer thoroughly to attend to. Early ſowing (earlier than is common) is evidently advantageous; which ſhould likewiſe be remarked, as a plowing, or perhaps two, may be ſaved with profit—an object of much conſequence to every huſbandman.

"EXPERIMENT X. p. 300.

"In 1766, marked 35 perches, as in the preceding trials, and ſowed them in the ſame days. The plowings were all repeated at the ſame time; but a variation made in all, of manuring the land with rotten dung, at the rate of about twelve loads per acre; which was on all plowed in by the earth preceding the ſowing.

The produce.

N° 1 ——— 3 ounces.
2 ——— 3
3 ——— 3½
4 ——— 6
5 ——— 5½
6 ——— 6
7 ——— 7½
8 ——— 8
9 ——— 8½
10 ——— 8¾
11 ——— 7½
12 ——— 7¼
13 ——— 6¾
14 ——— 7
15 ——— 7¼
16 ——— 7
17 ——— 6½
18 ——— 6½
19 ——— 5¾
20 ——— 5½
21 ——— 5½
22 ——— 5¼
23 ——— 5¼

N° 24

N° 24	———	5 ounces.
25	———	4½
26	———	4½
27	———	4
28	———	3¾
29	———	3
30	———	3
31	———	3¼
32	———	3
33	———	3
34	———	2½
35	———	2

“ The general reſult of this experiment ſeems to confirm the preceding one; only it is obſervable, that the manuring renders later autumnal ſowing more beneficial than in the unmanured: and it is, I think, conſiſtent with reaſon that this ſhould be the caſe. The very early and very late ſowings ſeem to be the worſe for the dung.

EXPERIMENT XI. p. 301.

“ In 1766, marked 35 perches of fallow, in the field of experiment VII. and ſowed them as before, on the ſame dates, and with the ſame plowings as the two laſt inſerted trials.

The produce.

N° 1	3¼ ounces.
2	3½
3	3½
4	6¼
5	5¾
6	6½
7	7
8	7½
9	6¾
10	7½
11	7¼
12	7½
13	7½
14	7¾
15	6¾
16	7
17	7
18	7
19	6½
20	6½
21	5¾
22	6
23	6¼
24	5½
25	5¼
26	5
27	5¼

N° 28	5 ounces.
29	5
30	4¾
31	3¾
32	3½
33	3¼
34	3¼
35	3

" This experiment is a confirmation of moſt of the preceding. From September 8th to November 24th, is the chief produce; which agrees much with the reſult of former trials. Very late ſowings, notwithſtanding the increaſe of plowings, are pernicious; and very early ones the ſame. There cannot be a greater proof of the importance of ſowing at the proper ſeaſon, than its more than balancing all the advantages of extra-tillage.

Experiment XII. p. 302.

" In 1766, marked 35 perches, and ſowed them as before, on a clover lay, in the field of experiment VII. The dates the ſame as in the preceding trials.

The produce.

N° 1 ——— 2½ ounces.
2 ——— 3¼
3 ——— 3¼
4 ——— 4
5 ——— 5¼
6 ——— 5¾
7 ——— 8
8 ——— 8¼
9 ——— 7½
10 ——— 7½
11 ——— 7
12 ——— 7¼
13 ——— 7
14 ——— 7
15 ——— 7
16 ——— 6¾
17 ——— 7
18 ——— 7
19 ——— 6¾
20 ——— 6½
21 ——— 6
22 ——— 6¼
23 ——— 5½
24 ——— 5
25 ——— 4¾
26 ——— 5
27 ——— 4½

N° 28 ——— 4¼ ounces.
29 ——— 4½
30 ——— 3½
31 ——— 3¼
32 ——— 3
33 ——— 3
34 ——— 2¾
35 ——— 2½

" From September 8th to December 22d, is the ſeaſon of the greateſt produce: it laſts longer in this trial than in former ones, which muſt certainly be attributed, in part, to the ſoil being a gravel. The other dates are good or bad, in proportion to their being near or far removed from that period.

" GENERAL OBSERVATIONS.

" I muſt obſerve upon this ſeries of experiments, that all were kept quite clean of weeds; which management occaſioned a variation of expence, according to the variety of ſeaſons.

" The early-ſown corn required a thorough weeding before winter; in reſpect of tillage after ſowing, this was all the difference in the expence (plowings excepted) between ſowing in July or Auguſt, and September or October.

The common farmers' principal objection to early ſowing was this point of weeds: "If," ſaid they, "we were to ſow ſo early, our crops "would be over-run with weeds, and deſtroyed "by them." But this would have been no objection to the practice, had it otherwiſe proved beneficial: for, upon a ſuppoſition that the fallow could not be freed ſo ſoon from weeds, yet the crop admits of the moſt exact cleanſing. I have often had broad-caſt crops thoroughly cleaned from all ſorts of weeds by hand-work; and, by an earlier growth of them, ſuch a work might be performed ſo much the eaſier: and, if ſuch a ſyſtem was not approved, that of hand-hoeing, with ſmall three or four-inch hoes, would effectually anſwer every objection. Upon the whole, I may aſſert from experience, that in broad-caſt ſowing the additional cleaning from weeds, ariſing from early ſowing, will not, upon an average of ſeveral years, amount to above 5 s. per acre, ſuppoſing the fallow to have been managed as it ought in common huſbandry, viz. the tillage to begin in the autumn, or before: but, as to the execrable method of not beginning to plow till after barley-ſowing, I certainly need not add that, with ſuch a conduct, a very early-ſown crop muſt ſtand a chance of being abſolutely deſtroyed. And I ſhould further obſerve, that theſe remarks are proportionably applicable to that ſeaſon which theſe experiments ſhew to be the moſt beneficial, viz. September, and the firſt fortnight in October; which is, upon the whole, a full month earlier than the Suffolk farmers venture their ſeed in the ground; conſequently, any objections to that ſeaſon, of this nature, are void of foundation.

" As to the dates of the time of ſowing, it, upon the whole, appears deciſively, that the month of September is the moſt advantageous; and next, with a ſlight inferiority, the firſt fortnight of October: ſucceeding months to April are all bad; the more remote the worſe; and that notwithſtanding all advantages of extra plowings. This reſult is peculiarly important for giving much tillage to land; for a certain decreaſe of product is evidently a pernicious practice, and ſuch as never could obtain, without the aſſiſtance of falſe ideas.

" The common idea of this neighbourhood is, that a fortnight after old Michaelmas is the prime wheat-ſeed ſeaſon; but theſe experiments, I apprehend, clearly prove the contrary.

" I

“ I never perceived any difference between the corn ſown at different ſeaſons, in reſpect of diſtempers, or being beaten down.”——So far the ingenious Mr. Young.

Looking over the memoirs of the Laudable Society of Berne for the year 1764, I was moſt agreeably entertained with M. de Sauſſure's account of the time of ſowing wheat. His experiments and reaſoning upon them do honour to the moſt conſummate philoſopher. The length of time employed in this intereſting part of rural œconomy, gives weight and ſolidity to his arguments. I think I cannot finiſh this eſſay in a more uſeful manner, than by tranſcribing the ſentiments of this moſt ingenious foreigner. The reader is deſired to carry in his mind, as he goes along, a juſt idea of diſtinction between this kingdom and the country of Swiſſerland, where the experiments were made.

“ On the 8th of Auguſt, 1740,” ſays M. de Sauſſure, to whom we owe theſe experiments, “ I ſowed a *coupe* * of wheat in the middle of a field, which required three *coupes* to ſow the whole of it, being of opinion that this might be a more favourable ſeaſon for ſowing that grain, than the time which is uſually choſen for it. This opinion was founded on my having often heard ſay, that thoſe crops were the beſt which had taken good root before the winter; and this, I thought, muſt be moſt effectually brought about by ſowing early. The reſt of this field was ſown in the latter end of September, the uſual time of ſowing in this country, that I might the more eaſily compare the two methods. Every part of the field had received the ſame manure and the ſame tilth, and was ſown with the ſame parcel of wheat.

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* The *coupe* is a Swiſs meaſure, nearly equal to two of our buſhels.

"The peaſants, who were witneſſes of what I did, declared, that if the wheat did not remain a month in the ground without ſprouting, it certainly would not yield any crop.—— The ſucceſs exceeded my hopes, and proved contrary to their prognoſtic.

"The wheat ſown in the month of Auguſt was, at harveſt, taller, thicker, and cleaner than the corn in the reſt of the field. In general there was a great deal of ſmutty wheat that year. The ſides of my ſmall field were much infected therewith, but there was not one ſmutty ear in the middle of it. Here is a very eſſential advantage of early ſowing, which this experiment promiſes.

"The cleanneſs of the ſheaves of the firſt-ſown wheat induced me to threſh them ſeparately, and they yielded a good deal more corn than thoſe which came off the reſt of the field.

"I repeated the experiment the next year. On the ſame Day, the 8th of Auguſt, I ſowed two *coupes* and a half of wheat upon narrow ridges; and in a ſmall field where the land lay flatter, and of which the ſoil was not all of equal goodneſs. The event was the ſame as before. The crop yielded eighty-five ſheaves, ſeven feet in circumference at the binding of the ſheaf. Twenty ſuch ſheaves give uſually from four to five *coupes* of corn, more or leſs, according to the goodneſs of the ſoil and ſeaſon. The ſheaves of this experiment yielded, in general, about a quarter of a *coupe* each. One place, of about twenty ſquare toiſes of eight feet, yielded ſix ſheaves; a very great crop. Theſe ſix ſheaves had indeed leſs grain in them than the others. The corn was laid; and theſe ſheaves yielded but an eighth Part of a *coupe* each, which was, however, an increaſe of ten for one. The corn was not laid in any other part of the field, the ſtrength of the ſtalks keeping it upright.

" From this time I continued to ſow every year a little earlier and a little more, and always with the ſame ſucceſs. In the year 1744, I ſowed a field all of the ſame kind and ſoil, and plowed into high ridges, each alternate ridge, one in Auguſt and the other in September. The crops were very different. The corn ſown in Auguſt was taller and thicker than the other. They were each reaped apart, that I might the better compare their increaſe. Twenty ſheaves of that ſown in Auguſt yielded four *coupes* and three quarters. The ſame number of ſheaves of the other yielded but three and three quarters, as is uſual elſewhere in the country.

" I now looked upon this time of ſowing as ſufficiently confirmed by experience, and have continued the practice conſtantly, beginning to ſow in the firſt week in Auguſt, and ending it as ſoon as poſſible. I compare my corn of every year with what is ſown later, and conſtantly find the compariſon is in favour of my method.

" In 1751, I found a remarkable difference between my crop and thoſe of my neighbours. There was a great fall of ſnow that winter, and the thaw was followed by frequent and alternate froſts and thaws. My neighbours reaped only a few ſheaves of corn, which grew where the ground was ſheltered by hedges, and the ſnow lay longer; whilſt on the whole of my ſowing, I reaped fifteen ſheaves for every *coupe* that was ſown, and they yielded me three *coupes* of good wheat. This was indeed a ſmall crop when conſidered by itſelf; but it was conſiderable when compared with the neighbouring no-crops, or nearly ſo. The ſuperiority of my crop was owing, not only to my early ſowing, but, I believe, alſo to my lands being laid in high ridges; the furrows carrying off the melted ſnow before the returns of the froſt.

" My neighbours began now to be ſenſible of the advantage of my practice, and I had the pleaſure of ſeeing many of them begin to ſow on the firſt of September, ſome even in the month of Auguſt. By degrees, their reaſon got the better of their prejudices.

“ I make no ſcruple now to declare, after an experience of twenty-three years, that the beſt time for ſowing wheat in this country (Swiſſerland) is the beginning, or at fartheſt the middle, of Auguſt. I ſow my heavy and my light lands at the ſame time, without any diſtinction. In the field on which I firſt began this practice, there is ſome light land, and ſome of it even mixed with gravel; yet there, as in every other ſoil, the early ſowing has conſtantly ſucceeded.

“ It is a common opinion, that if wheat goes into ſtalks before the winter, it periſhes. This is a maxim which paſſes from mouth to mouth, and is eſtabliſhed by tradition, without ever making the experiment; for that would at once give it the lie. I can declare, that my wheat, ſown in a good ſoil, conſtantly riſes into ſtems, which have ſometimes ſeveral knots, before the winter. They begin even to tiller; for I counted ſeven or eight ſtalks on one plant in the month of October. The wheat which I ſowed on the 8th of Auguſt, 1741, was as much grown in the month of November, as it uſually is in the latter end of April; yet it preſerved its verdure and ſtrength all the winter, which was not milder than common. There were ſome plants of rye which had gone into ear, and periſhed in the winter: yet they roſe again in the ſpring, the roots having remained intire.

“ Some people are frightned at the yellow colour which the early-ſown wheat is ſometimes of at the end of the autumn. It has frequently happened to mine, but was not attended with any ill conſequences. The cauſe of it ſeems to be the ſame with that which makes the leaves fall from trees. The juices which had hitherto riſen in great plenty, ſtop in the winter. The ſame happens to graſs which withers, but the roots ſuffer not; on the contrary, perhaps they increaſe the more. The wheat ſown later is leſs ſubject to this accident, becauſe its blades require leſs juices to ſupport them.

“ I ſow my wheat even in the greateſt drought, which, being frequent here in the month of Auguſt, would prevent my ſowing, was I to delay it on that account. My wheat, I think, makes a conſiderable progreſs during the dry ſeaſon; and tho' that progreſs be not apparent, it is, perhaps, not the leſs real. There is at all times in well-plowed grounds a moiſture, if not ſufficient to make the grain ſpring, at leaſt enough to ſwell and prepare it. I have never found any inconvenience ariſe from it, and have thought that my crops, which came from corn that had lain a fortnight or three weeks in the earth, were better than when a wet ſeaſon had brought them up ſooner.

" The grain which has undergone this preparation, ſprings up on the firſt rain; whereas they who delay ſowing till the rain comes, muſt alſo wait till the earth is again a little dried. This rain ſometimes continues too long, and may prevent the wheat's being ſown till winter, as happened this year to our neighbours in Savoy. They intended ſowing their wheat in October. It was not drought that cauſed this delay. It was indolence in ſome, and proceeded in others from their having too great a quantity of land to plow in proportion to their cattle. However it was, a month or five weeks rain prevented their ſowing till November, and their corn now, in May, at the time of my writing this, looks very poorly.

" By beginning to ſow early, I am never in danger of having my ſeed-time thrown back in this manner. It may perhaps be ſaid, that a continued drought may prevent my corn's riſing before the winter. The year 1746 ſhewed me that I had nothing to fear from this inconvenience. The ſummer of that year was very hot and dry. I ſowed my wheat in the beginning of Auguſt, in a very hot ſeaſon, and in a ſtrong ſoil with a gentle declivity to the ſouth; and as I ſow under furrow, the grain was lodged pretty deep. The dry weather continued through the autumn, and the few ſhowers that fell, did not penetrate deep enough to reach the grain. The winter was cold and dry till February. During all this time there was not a blade of my corn to be ſeen, except from a few grains which had fallen in the furrows. At length the rain fell plentifully in February, and the corn came up nearly as thick as if it had riſen in due time. The ſtalks became large, and the ears looked well, but did not contain much grain, the time for its vegetation being too ſhort.

"In the beginning of this practice, I was afraid that crops ſo ſuperior to others might too much impoveriſh the land which had not received any additional help, and thereby make it afterwards yield poorer crops. Full of theſe thoughts, after having reaped more plentiful crops from thoſe parts of my field which were ſown in Auguſt, 1744, than from the reſt, I ſowed the whole field the next year at the ſame time, and was impatient to ſee the event. I ſaw, with ſurprize, that the ſame ridges had a ſhadow of ſuperiority over the others. Whether this proceeded from the plants drawing a greater quantity of nouriſhment from the air before the late ſowing had riſen, and continued ſo to do by their larger ſurface; or whether the parts ſown, being ſix weeks leſs time in fallow, had loſt ſo much leſs by evaporation, I will not determine. A ſimilar obſervation is laid before us by the Sieur Grauque, of the mountain of Dieſſe. Recommending a certain mixture of grain for ſpring ſowing, he ſays that it is neceſſary to get as great crops as poſſible, becauſe, *the greater the crop the land bears, the leſs it is altered or impoveriſhed by it*; and on the contrary, *the leſs the crop is, the poorer the land becomes.*

“ We know that wheat ſown late in November will bring a crop, and that more plentiful than what is ſown in March: yet the progreſs which the former makes more than the latter, can be only in the roots; for the blades will ſoon be nearly the ſame in both. This is likewiſe the caſe in the ſeveral garden plants, where the ſeed ſown early gives a better crop than that of the ſame kind which is ſown late. Trees alſo tranſplanted in autumn, thrive better than thoſe planted in the ſpring; though, to appearance, the juices remain inactive during that interval.

"On theſe principles it will be an eaſy matter to account for the advantages which the wheat ſown in Auguſt has over that ſown later. The greater quantity of nouriſhment which it collects, renders the ſtraw ſtronger and bigger, and yields larger and better-filled ears. The grain itſelf is alſo larger. This I have found to be invariably the caſe in all the compariſons I have made.

"The ſtrength of the ſtraw is of great advantage in being able to withſtand ſtorms which would otherwiſe lay it. The moſt fertile parts of my land give ſometimes forty or forty-four ſheaves for one *coupe* ſown. The corn of this country, which is ſo thick as to yield that number of ſheaves, is conſtantly laid by the firſt ſtorm in June: mine ſtands till harveſt, though ſometimes bent in the middle, ſo that the ears hang down; but this does not in the leaſt diminiſh the crop. When the corn is exceeding thick, as that in 1741, it will be laid. That has happened but ſeldom. In order to prevent this inconvenience, our farmers take quite the contrary method. They ſow later, and ſay, that by this means the corn grows thinner, the ſtraw is ſhorter, and the ears lighter. But ſurely it is much wiſer to make ſure of a crop by rendering it more fruitful, than, by leſſening it, to prevent the danger.

“ I may aſcribe to the ſame practice, the advantage I have enjoyed of having no ſmutty or otherwiſe diſeaſed ears in my fields ever ſince I began to ſow early; or at leaſt but very few, when my neighbours have ſuffered thereby very much.”

ESSAY XV.

On the Connection between Botany and Agriculture.

THE juſtly celebrated Linnæus, in his Amænitates Academicæ, has traced out the dependence which Agriculture has upon Botany, in a very maſterly manner. He wiſhes the farmer to revive that old uſeful cuſtom of obſerving the times of budding, leafing, and flowering of plants and trees, becauſe theſe appearances ſeem to have been deſigned by Providence as our ſureſt guides in conducting rural matters. They aſcertain the exact times for ſowing, planting, and reaping. They are the beſt thermometers (if I may be allowed the expreſſion) which we can uſe, after they have been regulated and confirmed by experience.

If we look into the annals of hiſtory we may remark, that many nations have obſerved certain periods for ſowing, planting, and reaping, confirmed by the appearance of leaves on particular trees, or the migration of birds, which almoſt invariably correſponds with the leafing of thoſe trees.

There ſeems nothing unreaſonable in ſuppoſing the vegetable and animal world an excellent leſſon to the rational. In the ſacred hiſtory we are told, that the *Stork in the heavens knoweth her appointed times*; *and the turtle*, *and the crane*, *and the ſwallow*, *obſerve the time of their coming*; and we are reminded, that the leafing of the fig-tree uſually determines the approach of ſummer.

It is curious to ſee how ſteadily the antients have adhered to theſe principles. Theophraſtus, that parent of natural knowledge! has left us many remarks of this kind, which Heſiod has much improved. But no one, ſince Heſiod's time, conſidered the matter in its proper light, till the great Linnæus ſtarted forth to be Nature's more refined hiſtorian.

Among other things, Heſiod ſays, "That if it ſhould happen to rain three days when the cuckoo ſings, then late ſowing will be as good as early ſowing. That when ſnails begin to creep out of their holes, and climb up the plants, you muſt leave off digging about the vines, and take to pruning. That when the crane is heard, the time for plowing comes on."

Dr. Linnæus obſerves that, in Sweden, the "wood anemone blows from the arrival of the ſwallow, and that the marſh marigold blows when the cuckoo ſings. That barley is ſown when the birch tree leafs."

Theſe are ſufficient proofs to convince us, that if the improvers of agriculture conſidered botany as a neceſſary illuſtration of it, we ſhould be likely to advance our diſcoveries ſtill higher in the ſcale of perfection. Indeed, to do juſtice to the preſent age, our improvements in agriculture ſeem to be built more firmly upon the foundation of philoſophy and natural knowledge; a mode of proceeding which will undoubtedly be productive of the moſt pleaſing conſequences. For, by taking nature as a guide, the farmer may adjuſt his times of ſowing and reaping with more certainty. He may frequently inſure a good crop, by keeping his ſeed in the granary, till nature has pointed out a proper time for ſowing it.

In Sweden, the ſtudy of Agriculture is much in faſhion. And I date the æra of thoſe refined improvements from the time that Linnæus held out his diſcoveries to public view. He has himſelf made obſervations of theſe kinds in every country he examined. And he gives us a liſt of a great number of different perſons he employed to communicate to him the reſult of ſimilar experience. The only experiment of this kind made in England, is by the ingenious Mr. Stillingfleet, at Stratton, in Norfolk, in the year 1755.

If we would derive any benefit from theſe kalendars of Flora, they ſhould be made in every material variation of latitude, and ſhould be made for three or four years at the leaſt;

that the forwardneſs or backwardneſs of ſome chance ſeaſons might ſtill be conſidered as exceptions only to a general rule. With theſe helps, I can ſcarce imagine the farmer ignorant of the time of budding, leafing, flowering, ſowing, and reaping of any individual plant or graſs in the whole extenſive field of nature.

Some general knowlege of aſtronomy might likewiſe be of uſe in farther confirming theſe periods for ſowing and planting. It is beyond a doubt, that the antient huſbandmen eſteemed their practice not compleat without it. Virgil begins his Georgics with the ſame thought.

> Quid faciat lætas ſegetes; quo ſidere terram
> Vertere, Mæcenas, ulmiſque adjungere vites,
> Conveniat: ——
> Hinc canere incipiam. ——

Another grand uſe of botanical knowledge to the farmer, would terminate in this point: That as a kalendar of Flora would acquaint him with the duration and exiſtence of moſt plants; ſo he would be better able, in general, to ſuit the produce to the nature of his ſoil.

It is a juſt matter of wonder in this improving age, that ſo little attention ſhould be paid to the laying down our meadow and paſture grounds. The quantity of land that is annually laid down makes an attention to this branch of rural œconomy eſſentially neceſſary. Every farmer knows how to ſuit his grain to the quality of his ſoil, but few are acquainted with the nature and diſpoſition of the graſſes that cover the field. The ſurface of the earth is cloathed with a pleaſing and neceſſary variety of graſſes. Some delight in a moiſt ſoil; others prefer a dry ſituation; and yet ſo little do we obſerve this order of nature, that graſs-ſeeds of all kinds, good and bad, are promiſcuouſly ſown upon the ſame ſoil. A ſmall degree of reflection will teach us that vegetables, as well as animals, have a choice of ſoil. Therefore to ſtock our warm and dry lands with ſeeds produced upon wet meadows, is no leſs abſurd than if the farmer was to bring down his ſheep into the marſhes, and ſend his bullocks to the hills.

Of late there has been much encouragement given to the collecting graſſes by hand. It is here that the botaniſt becomes uſeful to the farmer. He knows from his kalendar of Flora what plants blow together, and if a mixture is required, can tell what ſpecies will render that mixture agreeable. For this uſeful purpoſe a ſmall degree of botanical knowledge is required. Nature is ever conſtant and uniform with herſelf. She points out to us the plants peculiar to every ſoil, if we could be prevailed upon to trace her along the walk ſhe delights to tread.

It is not an unuſual thing to ſee a piece of excellent land over-run with wild ranunculus and coarſe graſſes. In that ſtate it cannot maintain a ſtock in proportion to the goodneſs of the ſoil. Other lands of a much worſe quality, by being laid down with a more judicious choice of ſeeds, are found to produce larger and more profitable crops of graſs. This conſideration ought to awaken the attention of the farmer to a more ſkilful method of laying his lands.

In the preſent ſituation of things, the farmer is liable to the impoſition of the ſeedſman. If he purchaſes the ſeeds of weeds, he muſt expect a plentiful crop of them in return for the painful care that he has taken of his lands. This inconvenience, however, may, in ſome degree, be removed by the help of botanical knowledge. Let the farmer examine the ſeeds well before he buys them. If he has made himſelf converſant with the ſhape and appearance of the ſeeds of natural and good graſſes, and alſo of the ſeeds of ſuch weeds as infeſt the meadows, he will find it eaſy and familiar to determine the goodneſs of the ſample ſhewn him. Nay, he may diſcover with certainty whether the ſeeds grew upon a wet or dry ſoil, and conſequently may avoid the miſchief that ariſes from not ſuiting the ſeeds to the nature of the ſoil.

It is not only curious, but neceſſary, for the practical farmer to be able to find out the natural taſte of his cattle. Of this he may ſoon make himſelf acquainted, without entering deeply into the ſcience of botany. Cows, horſes, and ſheep, all differ in their taſtes, and are more partial to one ſort of graſs than another. And no wonder, when every plant delights in its proper ſoil; nay, every inſect has its own peculiar plant to feed upon.

Linnæus reckons up above two thouſand experiments, made by himſelf and his friends, on the taſtes of animals. He gives us tables not only of the number of plants each animal eats or refuſes, but the names of the plants themſelves. The former may be grateful to the reader, but the latter would not conveniently come within the compaſs of this eſſay.

Oxen eat	276	refuſe	218 plants.
Goats -	449	- -	126
Sheep -	387	- -	141
Horſes -	262	- -	212
Swine -	72	- -	171
	1446		868

If this plan was purſued, we ſhould not hear the farmer ſo often complain, that his paſtures are over-run with rough barren graſſes, which the cattle will not eat. In moſt paſtures we do not obſerve above half of the graſs eaten. The fact is this, that from neglecting the material point of ſuiting the palates of our cattle, graſſes odious to the taſte, and barren in themſelves, over-run and deſtroy the good.

It would both be ſuperfluous, and extending this eſſay to a tedious length, to reckon up ſuch graſſes as are barren in themſelves. But the following are the moſt prevalent in our meadow and paſture grounds. The carex tribe chiefly infeſt the moiſt parts of our meadows. The bent and hard meadow-graſſes over-run both meadow and paſture grounds. The mat-graſs is injurious to ſheep-walks. And the quick-graſs is too troubleſome to the farmer to need farther enumeration.

ESSAY XVI.

On the Nature and Properties of Marl.

IN many parts of this iſland the value of land has of late been greatly raiſed by the application of marl. It is divided into ſhell-marl and earth-marl. Shell-marl is compoſed of animal ſhells diſſolved. Earth-marl is a foſſil. Its colour is various; white, black, blue, red. Its hardneſs is as various as its colour; ſometimes it is ſoft and ductile like clay; ſometimes it is hard and ſolid like ſtone; and ſometimes it is extended into thin beds like ſlate. Shell-marl is eaſily diſtinguiſhed by the ſhells which always appear in it. But the ſimilarity betwixt earth-marl and many other foſſil ſubſtances, renders it difficult to diſtinguiſh them.

Marls, like all the ſubjects of the mineral kingdom, differ in their degrees of purity. But how to diſcover, with certainty, the purity of any given marl, is not generally known.

From theſe circumſtances we muſt conclude, that marl, though a ſubſtance of ineſtimable value, hath ſcarce ever been the ſubject of an attentive inquiry.

In this eſſay it is propoſed, firſt, to analyſe the different marls, as newly dug from the ground; and afterwards to examine what changes they ſuffer from being expoſed to the air.

SECTION I.

The moſt known properties of marl are, its efferveſcing with acids and fertilizing the ſoil to which it is applied*. By theſe two properties I was directed in the proſecution of my inquiry.

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* Dr. Hill, in his volume upon Foſſils, has ranked among marls many ſubſtances which do not effervefce with acids. But I cannot ſee by what reaſon ſuch an arrangement can be juſtified. Perhaps all the ſubſtances which we find in the claſs of marls have, with advantage, been employed in agriculture. But that is not ſufficient. We know that pure clay itſelf, applied to certain ſoils, produces the moſt happy effects. All Dr. Hill's

Among the ſubjects of the mineral kingdom, ſome are ſoluble in water, ſome not. Of the firſt, one only, the foſſil alkali, is poſſeſſed of properties ſimilar in any degree to thoſe of marl. For this ſalt, which is collected principally along the coaſts of the Mediterranean ſea, effervesces violently with acids, and has been, time immemorial, in the higheſt eſteem as a manure. From theſe circumſtances it might be ſuſpected, that a very intimate affinity ſubſiſts betwixt this alkali and marl, and that the ſimilar effects of both theſe ſubſtances proceed from the ſame cauſe. To ſatisfy myſelf with regard to this particular, I made the two following experiments.

EXPERIMENT I.

Two drachms of clay-marl, newly dug from the pit, were put into an ounce of water,

and

Hill's non-effervescent marls are poſſeſſed of the diſtinguiſhing properties of clay; and therefore ought in juſtice to be ranked among the argillaceous bodies. After comparing this author's definition of marl with his definitions of clay and bole, I can fix upon no particular character by which the firſt of theſe ſubſtances may, with certainty, be diſtinguiſhed from the other two. Marl ſeems, by his definition, to differ from clay and bole in degree of viſcidity only. But how ſhall the degree of viſcidity which conſtitutes a clay, or a marl, or a bole, be aſcertained? A very conſiderable number of earth-marls are of a ſtony hardneſs; but all marls, by Dr. Hill's definition, cohere ſlightly.

and for twelves hours digeſted with a conſiderable heat. The Marl, when ſeparated by filtration and dried, retained preciſely its original weight. The digeſted water was devoid of taſte and ſmell, and ſuffered no change from the addition of ſyrup of violets, or the acid of nitre. The event was in every reſpect the ſame, when a quantity of the ſame marl was boiled in water for a conſiderable time. Many varieties of clay, ſtone, and ſlate marls were treated in the ſame manner, with the ſame appearances.

EXPERIMENT II.

Two drachms of newly-dug ſhell-marl, free from moſs, fragments of putrid wood, &c. and previouſly dried, were digeſted as in the firſt experiment. The marl neither loſt any of its original weight, nor communicated to the water any thing diſcoverable by the trials mentioned above. The appearances were the ſame when this marl was boiled in water *.

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* Caution is here neceſſary. Shell-marl not only contains many ſeparate fragments of putrid wood, but is alſo very commonly mixed with parts of the moſſy ſtratum, under which it is generally found. If marl, containing either of theſe ſubſtances, is

From theſe experiments it is evident, that no ſalt, ſimilar to the foſſil alkali, is contained in marl. For all natural ſalts, of an alkaline quality, are diſtinguiſhed by their eaſy ſolubility in water, by effervеſcing with acids in the ſame manner when diſſolved, as before ſolution, and by converting the colour of blue or purple vegetable infuſions into green. But marl, neither when digeſted, nor when boiled in water, communicates any of its ſubſtance to that fluid; therefore contains nothing ſoluble by it, nor any ſalt of an alkaline, or any other nature. Beſides none of the waters, filtered from the marls in the preceding experiments, ſuffered any change from the inſtillation of the nitrous acid, or of the ſyrup of violets. From theſe circumſtances it is manifeſt, that marl does not contain the ſmalleſt proportion of an alkaline ſalt. And, as no other ſalt will account for the phænomena, this, added to ſome particulars mentioned above, renders any farther ſearch

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is employed in the preceding experiment, it never fails to communicate a bitterneſs and peculiar ſmell to the water. Beſides theſe properties, this water, upon the addition of any alkaline ſolution, acquires a milky hue, and lets fall a ſmall quantity of a white powder. That theſe effects proceed ſolely from the heterogeneous bodies mixed with the marl, is evident from this, that ſhell-marl, when perfectly pure, and freed by evaporation from moſſy water, never communicates any perceptible quality to water in which it is digeſted.

ſearch for a ſaline ſubſtance in marl unneceſſary.

SECTION II.

Being ſatisfied with regard to this particular, the affinity betwixt calcarious earths and marl next occurred to me. Calcarious earths efferveſce with acids, are remarkable for their fertilizing properties, and cannot, in a natural ſtate, be diſſolved by water. So far they agree exactly with marl. But their moſt characteriſtical qualities are, their diſſolving entirely in the mineral acids, and calcining to quick-lime. By theſe two properties ſuch earths may be diſtinguiſhed wherever they occur.

With a view to the apparent affinity betwixt calcarious earths and marl, I made the following experiments.

EXPERIMENT III.

To a drachm of newly-dug ſtone-marl, reduced to powder, I gradually added the muriatic acid, till no further efferveſcence enſued upon the addition. This mixture, diluted with a ſufficient quantity of water, was thrown into a filter of grey paper: A pure pellucid liquor paſſed through, and a groſs earthy ſubſtance remained behind at the bottom of the filter. This ſubſtance, when properly waſhed and dried, weighed juſt eighteen grains.

In this experiment, we find the marl divided into two different parts; the one carried off by the muriatic acid, and inviſibly ſuſpended in it; the other an earthy ſubſtance, on which that acid ſeems to have no influence. Having advanced thus far in the de-compoſition of our ſubject, the next ſtep is to examine into the nature of theſe two conſtituent parts.

SECTION III.

EXPERIMENT IV.

The ſubſtance which remained in the filter poſſeſſed, almoſt in every reſpect, the properties of clay. In drying, it concreted into a maſs of conſiderable hardneſs; made no efferveſcence with any of the acids; fell down and diffuſed readily in water; and was, by the action of fire, converted into a reddiſh-coloured brick. Twenty grains of ſuch a ſubſtance, extracted from the ſame marl, gave, by elutriation *, five grains of ſand. Hence the nature

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* This term is applied to the ſeparation of clay from ſand by means of water.

ture of the unſoluble part of this marl is abundantly evident.

It muſt be remarked, however, that neither the quantity nor compoſition of this unſoluble part is, in any two marls, preciſely the ſame. Clay, or clay and ſand, are, it is true, the conſtituent parts of it in all marls *; but the different proportions, in which theſe are mixed with the ſoluble part, are almoſt infinite.

EXPERIMENT V.

The reſidue of a drachm of clay-marl, which was eaſily diffuſible in water, weighed forty grains, and conſiſted of equal portions of clay and fine ſand.

EXPERIMENT VI.

A drachm of another clay-marl contained fifteen grains of unſoluble matter, which was altogether clay.

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* It muſt be obſerved, that the reſidue of all or moſt marls contains, beſides clay and ſand, a conſiderable number of flat ſhining particles. Theſe particles are unſoluble in acids, as is evident from their remaining in the reſidue. Few of them ſuffer any diminution of luſtre in the fire. Whence they appear to be flakes of foliaceous talc.

EXPERIMENT VII.

Forty grains of a ſmooth laminated marl afforded eight grains of a clay *reſiduum*.

EXPERIMENT VIII.

The reſidue of forty grains of a ſtone-marl weighed twelve grains, a third of which was ſand.

EXPERIMENT IX.

A drachm of another ſtone-marl gave only nine grains of unſoluble matter, moſtly clay.

EXPERIMENT X.

The reſidue of forty grains of another ſtone-marl * weighed ſixteen grains, thirteen of which were ſand.

EXPERIMENT XI.

A drachm of a friable ſlate-marl afforded a *reſiduum* of eighteen grains of yellow ſand.

EXPERIMENT XII.

A drachm of limeſtone contained twelve

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* I have here given the name of marl to ſome ſubſtances which perhaps, in ſtrict language, ought to go under another denomination; but they are generally accounted marls, and employed as ſuch indiſcriminately with the marly *ſtrata* contiguous to them.

grains of unſoluble matter, which was altogether ſand.

EXPERIMENT XIII.

A drachm of another limeſtone gave only ſix grains of reſidue, which appeared to be a ſlime.

EXPERIMENT XIV.

A drachm of ſhell-marl, dug out at the depth of two feet from the ſurface, contained thirty-ſix grains of unſoluble matter, which acquired little coheſion by drying, and conſiſted in a great meaſure of a very fine ſand.

Theſe are the moſt remarkable differences that have hitherto occurred to me in examining the *reſidua* of different marls. I thought it neceſſary to give a detail of them, both becauſe the compoſition of the unſoluble part of our ſubject is thereby demonſtrated, and becauſe the preceding experiments will afterwards ſerve to explain a difficulty which would not otherwiſe admit of an eaſy ſolution.

SECTION IV.

We muſt now return to the pellucid liquor which paſſed through the filter in Experiment III. As this liquor contains, in an inviſible ſtate, the ſubſtance which, in combination with the part examined in Section III. compoſed the original marl, if we can diſcover the nature of that ſubſtance, the nature and compoſition of marl will of conſequence be evident.

An alkaline ſalt, added to the ſolution of any other ſubſtance in an acid liquor, inſtantly precipitates that ſubſtance. The part of the marl diſſolved and carried off by the muriatic acid in Experiment III. had no affinity to an alkaline ſalt *; therefore a ſalt of this nature, added to that ſolution, cannot fail to ſeparate from it the ſoluble part of our ſubject, and conſequently to give us an opportunity of examining it to greater advantage.

EXPERIMENT XV.

With this view, the fore-mentioned filtered liquor was mixed with a ſmall quantity of a ſolution of ſalt of tartar. The mixture became immediately milky and turbid; but in a ſhort time recovered its tranſparency by the copious precipitation of a whitiſh powder. More of the alkaline ſolution was then added; and as a new lacteſcency and precipitation enſued, the addition was from time to time repeated, till it pro-

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* See Exper. I. II.

produced no ſuch effect. Then it was evident, that whatever the acid had carried off from the marl, was now thrown to the bottom. The precipitated powder, when ſeparated by filtration, waſhed and dried, weighed preciſely forty-two grains; which, added to the eighteen grains of unſoluble matter in Experiment III. makes up the original weight of the marl employed in that experiment. This powder was altogether inſipid; ſuffered no change from water; and was, after a very briſk efferveſcence, totally diſſolved both by the acid of nitre and of ſea ſalt.

The liquors filtered off from the unſoluble matters in all the experiments related in Section III. were ſeparately treated in the manner deſcribed above, and in every reſpect with the ſame appearances: Particularly the weight of each of the precipitated powders, added to that of its reſpective reſidue, equalled, with remarkable exactneſs, the original weight of the marl from which it had been extracted.

SECTION V.

Theſe precipitated powders are totally ſoluble in acid ſpirits; for it was by this ſolution that we obtained their ſeparation from the other parts of the marls in which they exiſted. The knowledge of this ſingle property, however, is not ſufficient to determine their nature. The changes produced upon them by the action of fire muſt be alſo conſidered.

EXPERIMENT XVI.

For this purpoſe ſeventy grains of powder, extracted, in the manner deſcribed above, from the marl of Experiment III. were for two hours detained in a ſtrong fire. The weight of the powder was thereby reduced to forty grains, and its colour from white changed to grey or aſhy. When water was poured upon this calcined ſubſtance, many air-bubbles roſe to the ſurface with a hiſſing noiſe, and as ſtrong a lime-water was in a ſhort time produced as I had ever obtained from any quick-lime.

The calcination of the powders extracted from the other marls was attended, in every circumſtance, with the ſame ſucceſs; that from ſhell-marl not excepted.

From theſe experiments, I think, the nature of marl is ſufficiently evident *. Marl conſiſts

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* Here it may be aſked, if ſuch is the compoſition of all earth-marls, whence comes it, that ſome earths of that kind, or what ſtrongly

ſiſts of two parts poſſeſſed of very oppoſite qualities. The one, clay, or a mixture of clay and ſand; the other a ſubſtance ſoluble in acids, convertible by calcination into quick-lime, and conſequently a real calcarious earth, differing in no reſpect from the calcarious earth of lime-ſtone and the ſhells of animals †.

From the foregoing experiments it is alſo manifeſt, that the nature of clay-marls, ſtone-marls, and ſlate-marls, is altogether the ſame. For marls of equal purity, and conſiſting of the ſame proportions of conſtituent earths, are found

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ſtrongly reſembles them, are ſo deſtructive to the growth of vegetables? In anſwer to this it muſt be remarked, that many foſſils, differing widely in their nature from marl, have frequently, from reſemblance, been employed as marl. Among the foſſils of this country, is oft-times found a ſpecies of the Pyrites, *Lapis atramentoſus* of Cramer, which in colour nearly reſembles ſome of the earth-marls. I have ſeen a bed of this which contained a conſiderable proportion of calcarious earth. It may occur among beds of marl; but, whenever it is employed in agriculture, its effects muſt be unfavourable.

† The very eſſence of marl ſeems to conſiſt in this earth; for that name is beſtowed on no ſubſtance that does not contain an earth of this nature. However all bodies, into whoſe compoſition calcarious earth enters, do not fall under the denomination of marl. To intitle them to this, they muſt fall into powder upon being expoſed to the air. Hence, the purity of marls will be in proportion to the quantity of calcarious earth in their compoſition.

found under all theſe different appearances. Different names have been affixed to them, from their different degrees of hardneſs, and the different diſpoſitions of the beds into which they are extended. But from what cauſe proceeds the diverſity in the coheſive power of marls, equal in the proportions of their conſtituent parts, is difficult to ſay.

It appears from the experiments related in Section III. that, in different marls, the proportion of the calcarious to the other earths is not always the ſame. As this diverſity may probably render a choice of marls for particular ſoils, if not neceſſary, at leaſt beneficial, a more minute account than that formerly given, of the proceſs for diſcovering the proportion of earths contained in any marl, may not be improper.

Having dried and powdered the marl to be examined, pour upon any given weight of it a ſmall quantity of water. To this mixture, well ſhaken, add a little of the acid of ſea ſalt *,

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* Any mineral acid may be employed with equal advantage, the vitriolic excepted. For, though this acid effervesces violently with all marls, it does not diſſolve their calcarious earths; it

and when the conſequent effervescence is over add a little more. Repeat this addition at proper intervals till no more effervescence enſues. Then throw the whole, with an equal or greater proportion of water, into a filter of grey paper, whoſe weight is known. When all the fluid parts have paſſed through, fill up the filter, again and again, with warm water. By this means the diſſolved particles of calcarious earth, adhering to the reſidue, or entangled in the pores of the paper, will be waſhed away, and nothing but what is really unſoluble will remain in the filter. This *reſiduum* with the filter muſt be compleatly dried and weighed. Then the difference betwixt its weight, and the original weight of the filter, gives you the weight of unſoluble parts contained in the marl under examination. This being known, the proportion of calcarious earth in the ſame marl is evident. The proportions of clay and ſand in it are diſcovered by ſubjecting the *reſiduum* to a proper elutriation. This operation is

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it only forms with them a whitiſh coagulum, which will not paſs through the filter.

In any trials that I have hitherto made with the vegetable acid, I have not been able by its means to extract all the calcarious earth contained in any marl. For, after the uſual filtration, the *reſiduum* always effervefced violently with the mineral acids.

is very ſimple, and performed thus: Having weighed the dry reſidue, mix and ſhake it well with a ſufficient quantity of water. After allowing a little time for the ſubſidence of the groſſer parts; let the water, with the fineſt particles of clay ſuſpended in it, be gently poured off. When this is done, add more water to the remainder, and, after ſufficient mixture and ſubſidence, pour that off likewiſe. In the ſame manner repeat the operation, again and again, till the water comes over perfectly pure. The ſubſtance which then remains is ſand, mixed, perhaps, with ſome flakes of talc; and whatever this ſubſtance wants of the weight of the reſidue employed, is the weight of pure clay carried away by the water in the proceſs of elutriation.

It may be here obſerved, that the effervescence enſuing upon the application of acids to marl, cannot be relied upon as a certain indication of the quantity of calcarious earth contained in ſuch ſubſtances. Numerous inſtances of the truth of this aſſertion have occurred to me. For the efferveſcence varies, both in violence and duration, according to the ſtrength of the acid employed; but it varies ſtill more according to the penetrability and other more ſecret circumſtances of the calcarious bodies.

SECTION VI.

I next examined what effects fire would produce upon marl in its natural ſtate. As many marls contain a very conſiderable proportion of calcarious earth, I expected that nearly the ſame changes would be produced upon them by calcination, as upon lime-ſtone.

EXPERIMENT XVII.

A piece of the marl of Experiment III. weighing eighty grains, was kept in a ſtrong fire for two hours. Its weight was thereby reduced to fifty-two grains, and its colour, from a blueiſh white, changed to a reddiſh brown. Its hardneſs was at the ſame time conſiderably augmented; and though, when immerſed in its natural ſtate into water, it gradually relented and fell down into powder; yet now it neither ſuffered any change from that fluid, nor communicated to it any thing perceptible by the ſight, taſte, or ſmell. Notwithſtanding this, when it was reduced to powder,

der *, it afforded, upon the affuſion of water, as pungent lime-water as any quick-lime could do.

EXPERIMENT XVIII.

The marl of Experiment VI. by burning loſt near a third of its weight, and acquired a very remarkable hardneſs. When put into water in this ſtate, it did not relent in the ſmalleſt degree, though naturally it diſſolved readily in it. The laminated marl of Experiment VII. ſuffered preciſely the ſame changes from burning.

EXPERIMENT XIX.

The marl of Experiment VIII. when burnt and thrown into water, did not fall freely into powder, but looſened into pieces, which eaſily yielded to the preſſure of the finger. This marl, before burning, diſſolved very ſlowly in water.

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* The pulverization of all burnt marls, that contain any conſiderable proportion of clay, is abſolutely neceſſary to extract a lime-water from them. Inattention to this circumſtance has, I believe, produced ſome miſtakes. When ſhell-marl is burnt, pulverization is ſeldom requiſite; becauſe this ſubſtance being naturally of a looſe and ſpungy texture, and acquiring little cohesion in the fire, allows the water an eaſy acceſs to its calcarious earth.

EXPERIMENT XX.

The marls of Experiments IX. X. XI. ſuffered, in their natural ſtate, ſcarce any perceptible change from water; but, when ſufficiently burnt, they ſwelled and fell down in water like lime-ſtone.

EXPERIMENT XXI.

A drachm of ſhell-marl, Experiment XIV. was by burning reduced to forty-two grains, and then ſpontaneouſly yielded a ſtrong lime-water.

From theſe experiments it appears, that the calcarious earth of marl is equally calcinable to quick-lime, whether it is expoſed to the action of fire before or after its ſeparation from the other earths.

It is now ſufficiently evident, that the nature of marl * has a very intimate affinity to that of lime-ſtone. A gentle gradation from the one to

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* By marls I mean ſuch calcarious ſubſtances as are viſibly reduced to powder by the influence of air and moiſture. Such only are real marls. Others, as thoſe of Experiments IX. X. XI. decline towards lime-ſtone.

to the other of theſe ſubſtances may be eaſily traced out; and it will be difficult, I believe, to eſtabliſh the preciſe limits of either. Both of them are found in continued *ſtrata*; both of them diſſolve in part, with conſiderable efferveſcence, in acids; and both of them yield by calcination a quick-lime. In the foregoing experiments, however, two very remarkable differences occur: By being expoſed to the air, marl falls down into duſt; lime-ſtone retains its original ſtability. On the contrary, after undergoing the action of fire, lime-ſtone is reduced to powder by the application of water; marl ſuffers no ſuch change. This diverſity cannot, with juſtice, be aſcribed to the different proportions of calcarious earth in theſe two bodies. For the marl of Experiment VII. did not contain leſs of this than the lime-ſtone of Experiment XII. and in the marls of Experiments III. VI. VII. the proportion of this earth was conſiderably greater than in the marls of Experiments X. XI. yet, after ſufficient burning, the latter relented in water, the former did not. Nay, when a part of a bed of ſtone, which contained only one third of calcarious earth, was calcined and put into water, it inſtantly fell down into powder; whereas marl, containing four fifths of calcarious earth, underwent no ſuch change from the ſame treatment.

The cauſe of the difference then muſt be ſought for in the unſoluble part of theſe ſubſtances. Upon comparing the Experiments related in Sections III. and VI. I obſerve that all the *reſidua*, conſiſting of any conſiderable proportion of ſand, were extracted from ſubſtances which, in a natural ſtate, ſuffered very little change from water; though, after calcination, water immediately reduced them to powder. On the contrary, the *reſidua* of clay were obtained from bodies poſſeſſed of juſt the oppoſite properties. That this obſervation will apply univerſally, I dare not venture to affirm; but it appears to point out a probable ſolution of the preſent difficulty. To explain this in the moſt intelligible manner, it is neceſſary to obſerve, 1*mo*, That dry clay ſuffers a very ſingular change from immerſion in water. For its particles, then gradually receding from mutual contact, come at length entirely to loſe their coheſive power; in conſequence of which, the whole maſs, after increaſing in its volume, crumbles down into powder. 2*do*, That clay, by the action of fire, not only acquires a conſiderable degree of hardneſs, but is at the ſame time ſo altered in its nature, that the water can no longer make any impreſſion on it. *3tio*, That ſand in its natural ſtate ſuffers, from the influence of water, no change as to the coheſion of its particles; and that it acquires no conſiderable hardneſs in the fire. *4to*, That calcarious earth, when uncalcined, ſuffers as little change from water as ſand does; but that, after calcination, it is affected in the ſame manner by that fluid, as clay is in its natural ſtate. Theſe things being premiſed, the difficulty is eaſily ſurmounted. Upon the expoſing of marl to the air, the clay in its compoſition, moiſtened from time to time by the rain and dews, gradually moulders away; and, in conſequence of this, the coheſion of the whole maſs is at laſt deſtroyed. On the other hand, when this marl is calcined, the increaſed coheſion of its clay locks in the calcarious particles, and, denying admiſſion to the water, ſupports the maſs againſt the action of this fluid *. Lime-ſtone, on the contrary, and other ſubſtances conſiſting of calcarious earth, or calcarious earth and ſand compacted into a ſolid maſs, undergo no change from being expoſed to the air; becauſe none of their conſtituent parts have their coheſion diminiſhed by the influence of moiſture. But, when theſe ſubſtances are calcined and thrown into water, as the calcarious particles then recede from mutual contact with a force which the coheſion of the particles of ſand, if there is any, is not ſufficient to reſiſt, the whole compoſition muſt immediately fall into powder *.

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* Stone-marls, upon being expoſed to the air, divide firſt into maſſes of a conſiderable bulk. Theſe diviſions run for the moſt part horizontally or perpendicularly, with reſpect to the natural ſituation of the marl. Upon examining the divided ſurfaces, I find them covered with a thin coat of very fine clay, with little or no mixture of calcarious earth. Hence it is evident, why the reſolution begins at the parts where this clay lies.

Thus

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* It would appear that, in clay-marls, the particles of clay are diſpoſed in ſuch a manner as to touch one another, and, at the ſame time, to prevent the mutual contact of the calcarious particles. According to this diſpoſition, each particle of calcarious earth will be ſurrounded with a coat of clay. It is difficult to conceive how, without ſome ſuch arrangement, the changes mentioned above ſhould be produced. Unleſs the clay cements the calcarious earth, water, which only influences the clay, would ſcarcely bring about the reſolution of marl; nor would the calcination of this ſubſtance, which tranſports the property of relenting in water from the clay to the calcarious earth, produce the effects aſcribed to it above. Beſides this, water, ſo far as is yet known, only deſtroys the attraction of the particles of clay to one another, not the attraction of thoſe particles to any other ſubſtance; therefore, unleſs the particles of clay contained in any marl were in mutual contact, the application of water to that marl would produce no effect. On the other hand, when marl of conſiderable purity is calcined, if the calcarious particles were in contact with one another, not even the increaſed coheſion of the clay would be able to prevent their ſeparation, conſidering the quantity of calcarious earth contained in ſuch marls

Thus it appears, that marls differ from other calcarious ſubſtances, only by containing a certain proportion of clay. On which account, the claſs of calcarious bodies will admit of a diviſion into ſuch ſubſtances as in the air fall down into powder, and ſuch as do not.

SECTION

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marls, and the force with which that earth, after calcination, explodes in water. But if you conceive the calcarious particles as ſeparately involved in clay, which in its natural ſtate readily falls down in water, and, after burning, denies admittance to that fluid, all the phænomena are eaſily accounted for. Beſides all this, facts are not wanting to juſtify the ſuppoſition of this arrangement. Acids, however ſtrong, cannot extract any calcarious earth from calcined marl, except ſuch particles as lie upon the broken ſurface; and when theſe particles are thus carried away, the ſurrounding particles of clay, though more eaſily ſeparated, ſtill retain their former ſituation and attachments; which ſhows that ſuch particles are fixed to one another, and can ſupport themſelves in their place without any aſſiſtance from the calcarious earth. But when water is applied to marl in its natural ſtate, it gradually makes its way through the whole maſs which it reduces to powder. This, therefore, is a proof that the calcarious particles of marl have no mutual coheſion, ſince the whole maſs moulders down as ſoon as the coheſion of the clay is deſtroyed. And, as no acid can find admittance deeper than the ſurface to diſſolve the calcarious earth in calcined marl, we may conclude, that taking out one particle of this earth does not open a paſſage to another; and therefore, that theſe particles lie in ſeparate cells. From what is here ſaid, we may plainly ſee the neceſſity of pulverization in Experiments XVII. and XXII. and likewiſe how it happens, that when the clay, mixed with a calcarious earth, is below a certain proportion, the compoſition, when burnt, cannot reſiſt the influence of water. It may be here aſked, how it happens that acids can find admittance to the

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SECTION VII.

The two following experiments were made with a view to diſcover what change the action of fire produced upon the calcarious earth of marl with regard to its ſolubility in acids.

EXPERIMENT XXII.

Thirty grains of the marl of Experiment III. were, by burning, reduced to twenty. Theſe

juſt

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calcarious earth of marls, even in their natural ſtate, as each particle is ſuppoſed to be ſurrounded by a coat of clay? As to this particular, it muſt be conſidered, that acids contain a conſiderable quantity of water, which acts upon the clay, at the ſame time that the acid is acting upon the calcarious earth. Hence it is that the addition of water to the purer acids, facilitates the reſolution of the marls to which they are applied. Beſides this, in all pieces of marl, ſome particles of calcarious earth muſt be expoſed. The acid, in diſſolving theſe, ſets at liberty their entangled air. This now reſtored to an elaſtic ſtate, puſhes every way with great force, breaks the ſhells of clay contiguous to it, and, by that means, expoſes more of the calcarious particles to the contact of the acid. Thus the ſolution is carried on.

Some of the foregoing reaſoning may be applied in favour of the following ſuppoſition. It is probable, that in a compound conſiſting of calcarious earth and ſand, the particles of the former ſurround and cement thoſe of the latter. From this arrangement it is, that when ſuch a compoſition is calcined and put into water, the whole relents into powder, tho' only the calcarious earth is affected. In the ſame manner, when acids are applied to this calcined ſubſtance, they find no difficulty, even without a previous pulverization, and without the aſſiſtance of efferveſcence, to reduce the whole to powder; becauſe they diſſolve the cement.

juſt taken from the fire, and powdered *, were mixed with a quantity of diluted acid of ſea ſalt. No viſible effervеſcence enſued upon the mixture; but a remarkable degree of heat was generated. When as much of the acid was added, as I judged neceſſary to diſſolve all the calcarious earth contained in the marl, I filtered the mixture in the uſual way. The reſidue weighed four grains, did not concrete by drying, and was conſiderably whiter than the reſidue of the marl in its natural ſtate. The filtered liquor was of a yellowiſh hue, and, upon the addition of an alkaline ſolution, precipitated twenty-eight grains of a reddiſh powder.

EXPERIMENT XXIII.

Twenty grains of ſhell-marl, calcined in Experiment XXI. generated, with the acid of ſea ſalt, a conſiderable degree of heat, but without any effervеſcence. The unſoluble reſidue weighed thirteen grains, and the powder precipitated from the filtered liquor, eighteen.

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* The caution formerly given with regard to procuring lime-water from calcined marl, muſt alſo be obſerved in the application of acids to this body; for, without a previous pulverization, the experiment is generally unſucceſsful.

Two circumſtances, worthy of attention, occur in theſe Experiments. The one is, the abſence of effervеſcence during the ſolution of the calcarious earth; the other is, the remarkable difference betwixt the weight of ſubſtance carried off from the marls by the acid of ſea ſalt, and the weight of the powders afterwards precipitated from that acid.

Both theſe unuſual appearances may be eaſily accounted for from Dr. Black's ingenious experiments *. As to the firſt, the effervеſcence which enſues upon the application of acids to any calcarious ſubſtance in its natural ſtate, proceeds ſolely from the expulſion of air contained in that ſubſtance. Calcarious earths are, by calcination, totally deprived of their air; therefore thoſe earths, in this ſtate, never can excite any effervеſcence with acids. Hence the abſence of any ſuch commotion in the two foregoing experiments is eaſily explained.

As to the other circumſtances, calcarious earths by calcination loſe about a third of their weight. This loſs is found to proceed from the expulſion of air and moiſture naturally contained

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* Edinb. Phyſ. Eſſ. vol. II. Art. 8.

tained in ſuch earths. Both this air and moiſture, and conſequently the original weight, are, according to Dr. Black's obſervations *, reſtored to ſuch calcined ſubſtances by diſſolving them in acids, and then preciptating them by an alkaline ſalt. As the marls employed in the foregoing experiments had undergone the action of fire, their calcarious earth would neceſſarily be deprived of its natural proportion of air and moiſture; on which account, the ſolution of this earth in the muriatic acid, and its ſubſequent precipitation, by reſtoring what was loſt in the fire, could not fail conſiderably to increaſe its weight. And from thence it happens, that the weight of the precipitated powders, added to that of their reſpective reſidues, equalled pretty exactly the weight of the marls before calcination.

It may be alſo remarked, that the burnt marl of Experiment XXII. yielded a ſmaller proportion of reſidue than the ſame marl in its natural ſtate did. For when this marl was examined as taken from the pit, its unſoluble parts were nearly a third of the whole; after undergoing the action of fire, they did not exceed

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* Treatiſe formerly cited.

exceed a fifth *. This difference, I imagine, is the effect of iron contained in the preſent marl. Iron in ore diſcovers none of its metallic properties, and conſequently is not then ſoluble in any of the acids †. But when a body containing

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* They did not amount to a ſeventh part of the weight which the marl had before it was put into the fire. For the weight of the marl then was thirty grains, the weight of the reſidue extracted after calcination was only four.

† From a late obſervation, I have ſome reaſon to doubt the truth of this aſſertion. Whilſt I was examining ſome ſhell-marl, the following unuſual appearances occurred to me during its effervеſcence with the muriatic acid: A pungent ſulphureous vapour ſtruck the noſe; when the effervеſcence was at an end, the acid had acquired a peculiar diſagreeable ſtyptic taſte, reſembling the taſte of the *tinctura martis*. Upon the addition of an alkaline ſalt to this liquor, when filtered, an okrey film roſe to the ſurface; and a brown-coloured powder fell to the bottom. Having re-diſſolved part of this precipitated powder in the acid of ſea ſalt, I added to the ſolution ſome drops of the tincture of galls. Inſtantly a deep black colour was produced by the mixture. The exiſtence of iron in the marl under examination being thus demonſtrated, I wanted to know what proportion of that metal was contained in this ſubſtance. For this purpoſe, having mixed fifty drops of the acid of ſea ſalt with one hundred and twenty drops of pure water, I diſſolved in this mixture ten grains of the precipitated powder above-mentioned; conſequently ſeventeen drops of this ſolution contained a grain of the powder. Into twelve ounces of water were put ſeven drops of this ſolution. In an equal quantity of the ſame water was diſſolved half a grain of pure ſalt of ſteel. To each of theſe were added forty drops of a tincture of galls. The water which contained

taining iron is calcined in contact with an inflammable ſubſtance, that metal immediately aſſumes its diſtinguiſhing qualities, and of conſequence becomes obedient to the magnet, and ſoluble in acids. Therefore when our marl, in its natural ſtate, was examined by the acid of ſea ſalt, the iron contained in it ſuffered no change, but remained in the filter as part of the reſidue. On the other hand, when this marl, ſurrounded on all ſides by burning pit-coal, was properly calcined, its iron became ſoluble in acids, and conſequently fit to paſs through the filter, with the calcarious earth inviſibly ſuſpended in the acid of ſea ſalt. Thus it is evident that, in all marls containing iron, the proportion of unſoluble parts muſt be diminiſhed by calcination. A proof of the exiſtence of iron in the marl under conſideration, is its acquiring a reddiſh caſt in the fire *, which all clays that contain iron are obſerved to do. That this iron remains with the reſidue, when the marl is analyſed

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tained our ſolution became thereby conſiderably darker in its colour than the other. Therefore ten grains of the precipitated powder contained more iron than fourteen grains and a half of pure ſalt of ſteel. This marl communicated none of its iron to plain water. About a third part of its ſubſtance was ſoluble in the acid of ſea ſalt.

* Experiment XVII.

lyſed in its natural ſtate, and paſſes off with the calcarious earth, when the analyſis is performed after the marl is calcined, is evident from ſome circumſtances in the foregoing experiments. For the calcarious earth, extracted from marl in its natural ſtate, was always white *; the reſidue by the action of fire became red †. On the other hand, the calcarious earth of calcined marl had a reddiſh appearance, and the reſidue was white ‡.

SECTION VIII.

All the foregoing experiments were directed towards the reſolution of marl. I next attempted an artificial compoſition of this ſubſtance.

EXPERIMENT XXIV.

Seven parts of pure chalk were mixed, and, by the aſſiſtance of water, well kneaded with one part of tough clay. This paſte, when dry, relented ſuddenly upon the application of water. Water alſo readily reduced it to powder, after a ſufficient calcination. From this, and the Experiments IX. and XX. it appears, that all proportions of clay and calcarious earth compounded together, will not reſiſt the influence of water applied to them after calcination.

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* Experiment XV. † Experiment IV. ‡ Experiment XXII.

EXPERIMENT XXV.

Four parts of chalk were properly kneaded with one part of clay, and dried. This mixture, when calcined and put into water, ſuffered no perceptible change. The event was the ſame, whatever proportion of clay was uſed; provided this was not leſs than the proportion employed in the laſt compoſition.

EXPERIMENT XXVI.

Four parts of chalk, one part of ſand, and one of clay, were well kneaded together, and dried. When this mixture was put into water after calcination, it cracked in ſeveral places, but did not fall down into powder. From this we ſee, that the addition of a little ſand to the proportions uſed in the laſt experiment, makes a compoſition unable, when ſufficiently burned, to reſiſt the influence of water. And this happens, becauſe ſuch an addition augments the ſurfaces to be connected farther than the clay can be properly extended. For this reaſon it is, that a greater proportion of ſand than what is employed in this experiment, gives a compoſition which the action of fire renders unable to reſiſt water in the ſmalleſt degree. Compare Ex-

Experiments VII. and VIII. with Experiments XVIII. and XIX.

EXPERIMENT XXVII.

Six parts of chalk, two parts of ſand, and one part of clay, gave a compoſition, which, when calcined and put into water, immediately fell down into powder. I have ſeen a lime-ſtone conſiſting of the ſame proportion of earths.

It may be remarked, that though the laſt compoſition, and that of Experiment XXIV. quickly relented in water after calcination, yet many little maſſes in both ſuffered no change. This was probably owing to ſome inequalities in the mixture, by which the particles of clay were in ſome places allowed to remain in contact with one another.

EXPERIMENT XXVIII.

Equal parts of quick-lime * and ſand were kneaded together and dried. In this ſtate the maſs ſuffered no change from water; but when properly burnt, it exploded in water with conſiderable violence.

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* I could by no means make crude calcarious earth cohere with ſand in ſuch a manner as to reſiſt either the ſlighteſt touch, or the influence of water.

Experiment XXIX.

A piece of old mortar, after calcination, fell down immediately in water. This mortar, examined by the acid of ſea ſalt, appeared to conſiſt of calcarious earth and ſand, in equal proportions *.

Thus it is manifeſt, that calcarious earth and clay conſtitute a ſubſtance poſſeſſed of the properties of marl; and that a mixture of the ſame earth and ſand, even in equal proportions, is not deſtitute of the moſt diſtinguiſhing characters of lime-ſtone. Theſe circumſtances ſerve to ſupport the account formerly given of the natural compoſition of marl and lime-ſtone, whilſt at the ſame time they ſhew that marls, conſidered as calcarious bodies, may ſurpaſs many lime-ſtones in purity. Marls, however, are limited in the proportion of their calcarious earth. They cannot, according to my obſervations, contain much above four fifths of it. Lime-ſtone may conſiſt entirely of this earth.

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* In the ſame manner, the proportion of ſand in any mortar may be eaſily examined; and, conſequently, the compoſition of ſuch mortars as have, for many ages, withſtood the effects of time, may be thus diſcovered.

From the affinity betwixt marls and lime-ſtone, we may ſee whence it happens, that a bed of the latter is often found interpoſed betwixt two beds of the former. The calcarious earth in both is the ſame. The ſubſidence of clay in the one caſe, and ſand or nothing in the other, along with that earth, makes all the difference. Among beds of marl, a bed of coarſe ſtone ſometimes occurs. This ſtone, however, I have generally found to contain a conſiderable proportion of calcarious earth; but the quantity of this earth was too ſmall to procure the ſtone the denomination of lime-ſtone; and the quantity of clay in it was not ſufficient to intitle it to a place among marls.

SECTION IX.

Having in this manner analyſed marl as newly dug from the ground, I next proceed to examine this ſubſtance after its expoſition to the air. The Experiments III. IV. XV. XVI. XVII. were repeated upon marls that had been expoſed for many months. The events were the ſame, as when the experiments were made upon newly-dug marl; nay, part of a *ſtratum* of ſtone-marl, after it had been expoſed for three years to the open air, and had undergone all the viſible changes that uſually proceed from ſuch an expoſition, diſcovered the ſame proportions of calcarious earth and clay, as when it was taken from the pit.

Marl, when uſed as a manure, is generally ſuppoſed to attract from the air a certain acid ſpirit, with which it combines into a neutral ſalt, the powerful promoter of vegetation. I ſhall here add an account of two experiments, made with a view to aſcertain the exiſtence of that ſalt.

EXPERIMENT XXX.

Two drachms of clay-marl, which had been expoſed to the air for ſix months, were digeſted, with a conſiderable heat, in ten ounces of water. This water, after twenty-four hours, was filtered off, and the ſame quantity again added. After the ſame ſpace of time, this ſecond water was alſo filtered off. The marl being then dried, wanted a grain of its original weight. None of the filtered waters ſuffered any change from the addition of an alkaline ſalt. Both of them were, by a gradual evaporation, reduced to the quantity of an ounce. This differed in no viſible manner from the waters before evaporation, except that, after ſtanding a little time, it depoſited a ſmall quantity of a grayiſh inſipid earth, which, after a very briſk efferveſcence, diſſolved intirely in the acid of nitre. Nothing but ſuch an earth remained, when the evaporation was puſhed to dryneſs.

EXPERIMENT XXXI.

Two drachms of ſhell-marl, which for three years had been expoſed to the open air, were treated preciſely in the manner deſcribed in the foregoing experiment, and in every reſpect with the ſame appearances. The marl, after digeſtion, wanted half a grain of its original weight. The filtered waters ſuffered no change from the alkaline ſolution, and left, upon evaporation, a ſmall quantity of calcarious earth.

Theſe two experiments ſeem to contradict the common opinion with regard to the operation of marl in agriculture; for the marls here employed had certainly been expoſed as long as might have been ſufficient for the attraction of a conſiderable portion of the aërial acid, and the conſequent formation of a ſenſible quantity of a neutral ſalt. But theſe marls evidently contained nothing of a ſaline nature. For, by digeſtion in water, the proper *menſtruum* of every ſalt, they ſuffered in weight no diminution of any conſequence. The grain wanting in Experiment XXX. and the half grain in Experiment XXXI. may be ſafely allowed as the conſequence of loſs of ſubſtance, which no attention can prevent in the proceſs of ſuch experiments. But ſuppoſing this diminution of weight really to proceed from the ſolution of ſome ſaline ſubſtance, ſuch an inconſiderable quantity of ſalt will by no means account for the effects produced by marl; therefore theſe effects muſt proceed from ſome other cauſe.

The filtered waters left, upon their evaporation, a ſubſtance which did not in the ſmalleſt degree partake of the nature of ſalt. Beſides this, an alkaline ſolution added to theſe waters produced upon them no viſible alteration; which would not have been the caſe, if they had extracted any thing of a ſaline nature from the marls. For, as marl contains no alkaline ſalt *, the calcarious earth alone of this ſubſtance could ſerve as a baſis for the formation of a neutral ſalt; and it is well known, that all ſuch neutral ſalts are, after ſolution in water, immediately decompounded by the addition of an alkaline ſalt, which never fails to throw the earth to the bottom in form of a white powder. Therefore, if our waters had extracted any ſalt from

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* Experiments I. II.

from the marls with which they were digeſted, the alkaline ſolution would infallibly have diſcovered it †.

It may be objected, that the heat employed in the foregoing experiments was too inconſiderable to promote the ſolution of the ſalt contained in the marls under examination. But, to obviate this objection, it muſt be conſidered, that the heat, in which theſe experiments were made, greatly exceeded any heat to which the ſoil in our climate is ever expoſed. From whence it is evident, that whatever proportion of ſalt our marls may acquire from the air, this ſalt never can contribute by its ſolubility to vegetation; and conſequently marls cannot act in the manner that is generally ſuppoſed. Beſides, to remove all doubt with regard to this point, I boiled in water, during an hour, two drachms of the marl of Experiment XXX. This marl, when afterwards ſettled by filtration and dried, weighed two drachms and a grain. The filtered water ſuffered no change from the alkaline ſolution. This experiment was repeated with the ſame appearances upon the ſhell-marl of Experiment XXXI. Hence it is manifeſt, that our marls, by expoſition to the air, had acquired nothing of a ſaline nature.

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† Having diſſolved twenty-ſeven grains of pure chalk in a drachm of the nitrous acid, and mixed the ſolution with five drachms of water, I found that one drop of this mixture could, by the alkaline ſolution, be diſcovered in two ounces of ſoft water. But no more than a ſixth part of that drop, at the utmoſt, can be conſidered as ſalt; therefore one drop, equal in weight to a grain of pure ſalt, will be diſcoverable in twelve ounces of water.

In Experiments XXX. XXXI. it is mentioned, that the digeſted waters left, upon their evaporation, a ſmall quantity of real calcarious earth. Leſt this earth ſhould be ſuſpected to proceed from ſome marly ſalt decompounded in the progreſs of the evaporation, it muſt be obſerved, that the pure fountain water employed in theſe experiments, depoſited, by the ſame treatment, a quantity of calcarious earth equal to what was afforded by the digeſted waters; and, from this circumſtance, we may perceive whence proceeded the increaſe in the weight of the marl which had been ſubjected to ſo long boiling.

Upon the ſurface of ſome marly rocks which looked towards the north, and had been expoſed time immemorial to the open air, I found a thin white effloreſcence. In many places, where water trickled down from the rocks above, moſs, to the thickneſs of ſome inches, had been in time accumulated, and was now cruſted over with a hard white ſubſtance. Below this cruſt, the different plants of moſs were found diſpoſed in a very regular manner, and ſoldered together by a ſubſtance ſimilar to the cruſt. Here I expected to have found the ſalt of marl, but could not, by any treatment, diſcover the ſmalleſt indication of it. The mineral acids, after a very briſk effervеſcence, diſſolved entirely both the eflloreſcence from the ſurface of the rock, and the matter which adhered to the maſs. From this circumſtance it appears, that theſe ſubſtances conſiſted ſolely of the calcarious earth of the marl, freed from the other earths, by the moiſture, &c. whoſe action it had for many years undergone.

Theſe marls were expoſed alone to the air. Whether, when incorporated with the ſoil, ſuch ſubſtances may be more readily converted, in their calcarious part, into ſalt proper for the nutrition of vegetables, experiment alone can determine. Some circumſtances in the manufacture of nitre ſeem to perſuade us that they may. On the contrary, obſervations are not wanting which appear to take greatly from the probability of ſuch an opinion; for marls are found to produce the moſt remarkable effects on light exhauſted ſoils, where they can find little or nothing proper for furthering the nitrous proceſs, or the production of any ſalt we are yet acquainted with. However that may be, I think we are authorized by the foregoing experiments to aſſert, that marl acquires nothing of a ſaline nature by being expoſed alone to the open air *.

If no ſalt is formed upon marl from its expoſition to the air, how does marl operate? An anſwer to this queſtion would neceſſarily lead us to conſider the operation of manures in general; a ſubject too extenſive and intricate to be diſcuſſed within the narrow limits of this eſſay.

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* The following obſervation, however, muſt not be concealed. Upon a *ſtratum* of marl, which, with others, had been expoſed for ages to the open air, I found a whitiſh ſaline efflorescence in conſiderable quantity. This efflorescence was moiſt, and diſſolved readily in water. An alkaline ſalt added to a ſolution of it immediately precipitated a calcarious earth. After ſeparating this earth by filtration, the remaining liquor afforded, by a proper evaporation, many diſtinct chryſtals of a cubical figure. They taſted like ſea ſalt, crackled in the fire, and, by the addition of the vitriolic acid, emitted copious ſuffocating fumes. Hence it appears, that the ſalt found upon this marl conſiſted of the muriatic acid united to calcarious earth. It is ſingular that no veſtige of this ſalt appeared upon any of the beds of marl but one, and this one had nothing peculiar either in its compoſition or ſituation. It differed from the reſt in this only, it was poſſeſſed of a greater degree of moiſture.

ESSAY XVII.

On Drill-Sowing.

THE anatomical inveſtigation of the roots of wheat and other grain, has convinced me of the neceſſity of placing all kinds of ſeeds at a certain depth in the earth, in order to their producing vigorous and healthful plants. For this wiſe purpoſe a variety of drill-plows have been invented and recommended; but from the expence attending the purchaſe, and the extreme complication of their ſtructure, there is not an inſtrument of that kind, as yet diſcovered, that is likely to be brought into general uſe.

When I ſpeak of the drill-plow, I do not connect the idea of its working with the horſe-hoe. I here conſider it only as an inſtrument for ſowing land in equi-diſtant rows, which, by opening a furrow, ſhedding the ſeed and covering it, leaves the land ſtocked with plants in the manner of broad-caſt ſowing. Grain ſown by the hand, and covered by the harrows, is placed at unequal depths; the ſeeds conſequently ſprout at different times, and produce an unequal crop. When barley is ſown late, and a drought ſucceeds, the grain that was buried in the moiſture of the earth ſoon appears, while ſuch as was left near the ſurface lies baking in the heat of the ſun, and does not vegetate till plentiful rains have moiſtened the ſoil. Hence an unequality of the crop, an accident to which barley is particularly liable. The ſame obſervation, but in a more ſtriking manner, may be made upon the ſowing of turnips. It frequently happens that the huſbandman is obliged to ſow his ſeed in very dry weather, in hopes that rain will ſoon follow, and either rolls or covers it with a buſh-harrow. We will ſuppoſe that, contrary to his expectarions, the dry weather continues. The ſeed, being near the ſurface, cannot ſprout without rain The huſbandman is mortified at his diſappointment, but is ſoon ſatisfied and made eaſy by a perfect acquieſcence in what he thinks is the *will* of Providence. The ſcourge that he feels muſt not be placed to the diſpenſation of Providence, but has its ſource in the ignorance of the man himſelf. Had he judiciouſly buried the ſeed in the moiſture of the ſoil with the drill-plow, or harrowed it well with the common harrow, his ſeed would have vegetated in due ſeaſon, and bountifully repaid him for his toil.

The man that expects the ſeed to vegetate by heat alone, little knows the immutability of nature's laws. Heat and moiſture, when combined, unfold the particles of matter cloſely connected in the ſeed, and, by a kind of fermentation, bring the living principle into action.

The huſbandman that knows and ſtudies theſe ſublime truths, will often diſcover his want of ſucceſs in his want of knowledge. Such a man will never repine at Providence, but, amidſt the adverſe calamities of ſeaſons, will at all times look up to the Deity with comfort and ſatisfaction.

Reflections upon this ſublime ſubject cannot be brought down to the level of vulgar minds. Modes more familiar will, in general, be better underſtood, and more agreeably received. All mankind are not Philoſophers.

In the year 1769, I prepared a fifteen-acre cloſe for turnips. The land was in fine condition as to lightneſs, and had been well manured. On the 24th of June, I ſowed fourteen acres of this field, broad-caſt, and harrowed in the ſeed with a buſh-harrow. The remaining acre I ſowed on the ſame day with the drill-plow, allowing fourteen inches between each row, and ſet the ſhares near two inches deep. At the time of ſowing, the land was extremely dry, which induced me to make the experiment with the drill-plow; knowing that I could place the ſeed into the moiſture of the ſoil. From the time of ſowing to the fifth day of July we had a continual drought, ſo that the broad-caſt ſeed did not make its appearance till about the 8th of that month, at which time the drill turnips were in rough leaf, having appeared upon the ſurface on the ſixth day after ſowing.

In the drieſt ſeaſons, at the depth of two inches, or leſs, we are ſure of finding a ſufficiency of moiſture to make the ſeed germinate. When that is once accompliſhed, a ſmall degree of moiſture will carry on the work of vegetation, and bring the tender plant forward to the ſurface.

When extreme dry weather obliges the broad-caſt farmer to ſow late, he has no opportunity of ſowing a ſecond time if the fly ſhould get into the field. The drill ſecures him, in ſome degree, againſt that misfortune, by giving him a full command over the ſeaſons.

I do not confine the excellence of the drill-plow to turnip ſeed: It is an uſeful inſtrument for ſowing all kinds of grain. By burying the ſeed at an equal depth, it ſecures an equal crop in all circumſtances of the weather. But this is not the only conſideration to the cultivator. It ſaves near one half of his ſeed, which is an object of importance to the tillage-farmer.

In order to be clearly underſtood upon this ſubject, I beg leave to obſerve, that I do not here recommend the drill-plow as a good inſtrument for ſowing turnip ſeed, unleſs when the weather is ſo dry and ſultry as to give the farmer reaſon to apprehend danger from the late ſprouting of the ſeed. When the weather favours germination, the broad-caſt method, by being more expeditious and leſs expenſive, is much more eligible.

When the farmer chooſes to introduce the horſe-hoe, the drill muſt then be recommended in all ſeaſons, on account of its diſtributing the ſeed in rows. The ſhares muſt be placed deeper or ſhallower according to the dryneſs or wetneſs of the ſeaſon.

Was I to give my opinion upon the beſt method of raiſing turnips, I ſhould not heſitate one moment to declare in favour of the drill and horſe-hoe, with intervals of three feet; but an inlargement of this ſubject does not come within the idea of the preſent eſſay, which only reſpects the drill culture, in equi-diſtant rows, independent of the horſe-hoe.

Having ſufficiently inlarged upon the neceſſity of lodging the turnip ſeed within the earth during an extreme drought, I ſhall now proceed to an experiment made upon barley, with a view to recommend the ſowing of that grain, as well as all others, by the drill-plow, in preference to the cuſtomary method.

In the ſpring of the year 1769, I ſowed an acre of barley, in equi-diſtant rows, with the drill-plow, in a field which was ſown with the ſame grain, and upon the ſame day, broad-caſt. The broad-caſt took three buſhels per acre; the drill required only ſix pecks: This circumſtance is worthy of obſervation. The drills were eight inches aſunder, and the ſeed was lodged about two inches within the ſoil. The drill acre was finiſhed within the hour, and the moſt diſtinguiſhing eye could not diſcover a ſingle grain upon the ſurface.

In the courſe of growing, the drill barley ſeemed greener, and bore a broader leaf than the broad-caſt. When the ears were formed throughout the field, the ear of the drill barley was plainly diſtinguiſhed to be near half an inch longer than the broad-caſt, and the grains ſeemed fuller and better fed. This appearance occaſioned a general ſurprize, and I confeſs I was at firſt at a loſs how to account for this apparent difference.

Reflecting upon ſome experiments that I had made upon the roots of wheat, I was induced to dig up ſome roots of the drill and broad-caſt barley, and was moſt agreeably ſurprized to find the cauſe of the difference to be in the roots. The pipe of communication between the *ſeminal* and *coronal* roots of the drill-barley, was conſiderably longer than the broad-caſt. And upon that appearance I was convinced that the length of the ear, and the ſtrength of the ſtraw principally depended. I ſhall not here repeat what I have formerly advanced upon the ſhape of the roots of wheat. The curious reader will find that ſubject clearly and ſatisfactorily explained in the fifth eſſay of this book. Without an attention to this ſimple mechaniſm, it is impoſſible for the cultivator to have any adequate idea of the vegetation of corn. It is matter of ſurprize that ſuch a ſelf-evident truth ſhould have hitherto eſcaped the obſervation of naturaliſts. Upon it the doctrine of top-dreſſings depends. Every perſon knows their uſe, but few can explain the manner of their operation. But to return.

The product of two hundred ſquare yards of the broad-caſt and drill barley was carefully houſed, and afterwards thraſhed out. The drill exceeded the other nearly one fifth in meaſure, and being a bolder and better grain, weighed heavier, at the rate of two pounds in the buſhel.

From the experience that I have had of the drill-ſowing, I can recommend it as a moſt rational and judicious practice. But as it has many difficulties to overcome, I apprehend it never will be brought into general uſe. A proper inſtrument is wanting that would come cheap to the farmer, and have the requiſites of ſtrength and ſimplicity to recommend it. The preſent inſtruments cannot, by any means, be put into the hands of common ſervants. Should we ever be ſo happy as to ſee this objection removed, it is probable that all kinds of grain will be cultivated in drills. Corn growing in that manner has a freer enjoyment of air, and the farmer has an opportunity of hand-hoeing and weeding without injury to the growing crop. This is an object of the utmoſt conſequence in the cultivation of beans and winter corn.

Wheat placed into the earth by the drill plow, is not liable to be turned out after froſts: The *ſeminal* root ſerves the purpoſes of an anchor. This is a conſideration of great conſequence to the farmer.

Much more might be advanced upon this curious and intereſting part of agriculture, but I flatter myſelf that theſe looſe thoughts will be the means of awakening the attention of others, who have more leiſure and greater abilities than I have.

After what I have advanced it will be needleſs to obſerve, that in this eſſay I only mean to recommend the drill-plow for ſowing the land in equi-diſtant rows, inſtead of diſtributing the ſeed by the hand in the manner called broad-caſt. The drill, when connected with the horſe-hoe, conſtitutes quite a different ſyſtem, which has great merit when judiciouſly conducted.

It will not be improper to obſerve in this place, that moſt gentlemen who have favoured the public with comparative experiments between the drill, in equi-diſtant rows, and the broad-caſt, or old method, have choſen an improper diſtance between the rows, and by that means rendered their comparative trials inconcluſive. A foot is the diſtance generally taken, which, beyond doubt, will not only encourage the growth of weeds, but alſo prove a conſiderable loſs of land. The diſtance ſhould never exceed eight or nine inches, and then the comparative trial would be concluſive, as both methods are ſuppoſed to be conducted in the moſt perfect and advantageous manner.

The inſtrument that I have hitherto uſed for drilling of grain, is the invention of the ingenious Mr. Craick, and made by Mr. Creighton, Coachmaker in Edinburgh. It works with four coulters, and is the compleateſt inſtrument of the kind that I know of. The price is twelve pounds. One man, a horſe, and a boy can eaſily ſow four acres a day: ſo that if I was only to eſtimate the ſaving in ſeed, I ſhould readily recommend the drill-ſowing in equi-diſtant rows, as a method worthy of national attention.

Mr. Benſon, of Stainly, near Ripon, is the only farmer that I know of, who conducts his whole farm in this œconomical and judicious manner.

ESSAY. XVIII.

On Manures, and their Operation.

IT is obſerved, that there are ſubſtances, which, when mixed with the earth, greatly promote vegetation. Theſe are called manures. To apply manures in ſuch a manner, as moſt effectually to promote vegetation, it is of importance to know their natures, and the ways in which they operate. This is the more neceſſary, as, without it, we cannot know how to apply them in the moſt proper manner to the different ſoils.

To inquire into theſe things is the deſign of this eſſay.

Manures operate in all the different ways by which vegetation is promoted.

They operate, by communicating to the ſoil, with which they are mixed, the vegetable food which they contain; by communicating to it a power of attracting this food in greater plenty from the air; by enlarging the vegetable paſture; and by diſſolving the vegetable food which it is already poſſeſſed of, and fitting it for entering the roots of plants.

Manures are very different in their natures. Some of them operate in all the ways mentioned, and there are none of them that do not operate in more ways than one.

Great miſtakes have ariſen, from ſuppoſing that manures operate only in one way. None have been attended with greater loſs, than ſuppoſing that they ſerve only to divide the ſoil, and that tillage may be ſubſtituted in their place. This is Mr. Tull's opinion; and is, indeed, the fundamental principle of his horſe-hoeing huſbandry.

Before one changes the ordinary practice of agriculture, in ſo important a point as baniſhing manures from his fields, the good effects of which are ſo obvious; he muſt be certain, that the principle which determines him to ſo important a change, is itſelf well founded.

Mr. Tull has endeavoured to prove, that earth is the food of plants; and hence infers, that to divide the earth into minute particles, by which it is fitted for entering their roots, is all that is neceſſary in agriculture: And this, he aſſerts, may be done by tillage, without manures.

But it is abundantly evident that other principles, beſides earth, are in the compoſition of this food: And, if this is true, the want of manures, which provide theſe other principles, cannot be ſupplied by tillage.

Suppoſing we allow, with Mr. Tull, that earth is the food of plants, yet ſtill it does not follow, that tillage may ſupply the place of manures. It is certain, that every particle of earth which we obſerve, is not of the kind that is the food of plants. Every ſoil is a compoſition of different earths; ſeveral of which, it is obvious, are not of this kind.

The great difference in ſoils, equally pulveriſed, is a plain and convincing evidence of this. Now, let it be obſerved, that the earth contained in dung is of this kind; it has already been food to plants, and therefore though all that is contained in the greateſt quantity of dung laid on at one time, is but ſmall in proportion to the quantity of ſoil employed in vegetation, as Mr. Tull juſtly obſerves; yet it may be conſiderable in proportion to the quantity that is really the food or *pabulum* of plants. If the quantity of earth contained in the quantity of dung commonly laid on at one time, is compared with the quantity of earth contained in the richeſt crop, it will be found ſeveral times larger; and therefore, by the laying on of this dung, food is provided for ſeveral good crops.

Beſides, let it be obſerved, that the mechanical action of the plow cannot increaſe the number of the particles by which plants are nouriſhed; they are ſo ſmall as not to be obſerved in water. Mr. Tull ſuppoſes, that they are as ſmall as thoſe upon which the colour of bodies depends. Now, though pounding earth in a mortar may perhaps do ſomething to increaſe them, yet the action of the plow can never be ſuppoſed to do it. The plow can do no more than open the ſoil, or enlarge the paſture of plants, and allow them to extend their roots in ſearch of their food, but does not increaſe the quantity of it; and therefore tillage cannot ſupply the place of dung, which not only opens the ſoil by its fermentation, but alſo increaſes the vegetable food by the earth which it contains.

It may be further obſerved, that the fermentation raiſed by dung continues for a conſiderable time; ſo that though, by plowing, the ſoil may be as completely divided as by the fermentation of dung, yet it will not continue ſo; for, after ſeed is ſown, the artificial paſture raiſed by plowing is continually decreaſing while the crop is growing; whereas the artificial paſture, raiſed by the fermentation of dung, is continued by the continuance of this fermentation; and therefore, though in the horſe-hoeing huſbandry, the want of dung may be ſupplied by hoeing, yet, as Mr. Tull indeed obſerves, dung is ſtill neceſſary in the old huſbandry.

If perſons attentively conſider the effects of manures, it will appear that they operate in all the ways mentioned.

Manures are found to enrich the beſt pulveriſed ſoil, and to do this again and again, after it is exhauſted by crops. It is almoſt an univerſal practice to lay dung upon land that is kept conſtantly in tillage, once in three, four, or five years. It is obſerved, that after the dung is laid on, the land becomes rich, and that the crops turn gradually worſe and worſe, till the whole virtues of the dung are exhauſted; and it is alſo obſerved, that immediately upon the dung being again applied, the land becomes rich as before. It is natural to conclude from this, that dung promotes vegetation by increaſing the quantity of the vegetable food.

It is found, that ſome manures loſe part of their virtues by being long expoſed to the air. After dung is ſufficiently rotten, the longer that it lies it becomes of leſs value, and does not enrich ſo large a quantity of land as when uſed in proper time. The dung of cows dried upon their paſture, gathered, and laid upon other land, is ſcarcely to be diſcerned in its effects on the crops produced: The ſame quantity applied, whether carried from the cow-houſe, or by folding the cattle, enriches the land. From this it is obvious, that this kind of manure contains the vegetable food in itſelf, and does not receive it from the air.

It is found that ſome manures operate the ſooner, and with the greater violence, the longer they are expoſed to the air, before they are uſed. Lime and marls are of this kind; the longer they lie expoſed, they operate the ſooner; and it is obſerved, that they have a ſtrong power of attracting the virtues of the atmoſphere. From theſe things it is reaſonable to infer, that theſe manures operate, by communicating to the ſoil with which they are mixed, a power of attracting the vegetable food from the air.

It is obſerved, that ſome manures exhauſt land of its vegetable food, and do not reſtore it again when immediately applied. This is found to be the caſe with lime. Land thoroughly limed has been found to carry many very good crops; by degrees, however, the virtues of it have been exhauſted, and the land reduced to a worſe ſituation than before the lime was laid on. In this ſituation lime has been applied a ſecond time, but its effects found to be far inferior to what they were when firſt applied. This is ſufficient to convince us, that this manure operates by diſſolving the vegetable food which it meets with in the ſoil, and fitting it for entering the roots of plants.

It is certain, that all kinds of manures open the ſoil. Any perſon will be convinced of the truth of this, who will take the trouble to compare a piece of land, on which dung, or any other manure has been laid, with a piece contiguous that has not been manured; he will find the one much ſofter, much more free and open than the other. It muſt be allowed, therefore, that all manures operate by enlarging the vegetable paſture.

Manures are commonly divided into claſſes. Some divide them into natural and artificial; others divide them into the foſſil, the vegetable, and the animal, and treat of them in order, as belonging to each of theſe claſſes.

The manures belonging to ſome of theſe claſſes differ, both in their nature and operation, from thoſe in the other claſſes. Some of them likewiſe differ from others in the ſame claſs. The dividing them into claſſes, therefore, ſerves no purpoſe. All that is neceſſary is, to treat of the different particulars which the farmer can command, without conſidering to what claſs they belong.

Dung is commonly uſed to ſignify not only the excrement of animals, but alſo all rotten vegetables, when uſed as manures. In treating of it in this eſſay, we underſtand it in the firſt ſenſe of the word.

The food of animals, reduced to a corrupted ſtate, conſtitutes dung. The ſtomach diſſolves that food, and reduces it to a ſtate of putrefaction much ſooner than is done by the air. It is by being in this ſtate of putrefaction that the juices, fit for the nouriſhment of the body, are conveyed by the lacteals into the blood. While bodies are in a ſound ſtate, their parts adhere firmly together, and they are incapable of being turned into the parts of other bodies. To render them incapable of this, they muſt be reduced to their firſt principles. This is done by corruption. It is obſerved, that by corruption all the parts of bodies are relaxed, and the ſalts, oils, and other juices which they contain, from being fixed are made volatile. It is by being reduced to this ſtate in the ſtomach, that the things which the animal feeds upon become nouriſhment to it, and are turned into parts of its body.

All the juices contained in the things which animals feed upon, are not exhauſted by the guts; many of them, along with the earthy part of the food, are thrown out. There is no doubt that ſome of the earthy part of the food goes alſo to the nouriſhment of the animal; but as the earth is rendered volatile by the ſalts and oils, there muſt be but a ſmall quantity of it, in proportion to the quantity of theſe, exhauſted by the animal; and therefore in the dung there muſt be a great quantity of earth in proportion to the other principles. However, as the dung contains all the principles of the food, we may conſider the dung of thoſe animals that feed on vegetables, as vegetables in a putrefied ſtate.

Of the ſame nature is the dung of animals that feed upon other animals. Vegetables are the original food. All animals either feed on pure vegetables, or on other animals that feed on vegetables. Animals that feed on vegetables are made up of the ſame things with vegetables, only under a different form; and therefore the dung of animals that feed upon theſe, is ſtill to be conſidered as vegetables in a putrefied ſtate.

Chemiſts inform us, that dung is compounded of the ſame principles of which vegetables are compounded; of water, air, oils, ſalts, and earth. The earth which it contains is of the abſorbent kind, and attracts the other principles. They alſo inform us, that dung attracts and ferments with acids, and by this fermentation produces ſalts. A quality of ſalt, as was before obſerved, is to attract and diſſolve oils, and make them capable of being mixed with the water.

If theſe qualities of dung are conſidered, it will appear that it promotes vegetation in all the different methods mentioned.

It promotes vegetation by increaſing the vegetable food. It is compounded of the ſame principles of which the vegetable food itſelf is compounded, as we endeavoured to ſhew when treating of the food of plants. This is alſo confirmed by the experience of all places and all ages; and it is what no perſon will doubt of, who conſiders that it has the ſame effects upon land of all kinds, and in all ſituations.

It promotes vegetation by enlarging the paſture of plants; it attracts acids from the air and ſoil; and, by raiſing a fermentation with them, thereby ſeparates the particles of the ſoil with which it is mixed. Every farmer knows the truth of this from experience. The land upon which dung is laid, tho' naturally ſtiff, becomes ſoft and mellow, and is more eaſily plowed than before.

Dung, we have ſaid, enlarges the paſture of plants, by attracting acids, and fermenting with them. Theſe acids are in the ſoil and air. They are in the ſoil; for the ſoil produces acid plants. Chemiſts tell us, that the neutral ſalt found in ſoil is compounded of an alkaline ſalt, ſuch as is found in vegetables, and an acid ſpirit. All alkalies are ſtrong attractors of acids; ſo that, in the proceſs of an experiment upon ſoil, perhaps it may be difficult to keep them ſeparate, though they may exiſt ſeparate in it. The acid plants prevent theſe from mixing; or, perhaps, have a ſtronger power in their veſſels to ſeparate them than other plants have.

But though there may be no acids in ſoil, excepting in the compound of neutral ſalts, yet there is no doubt but they are in the air. Chemiſts find this by innumerable experiments. Aſhes, when expoſed to the air, produce neutral ſalts; the application of acids has the ſame effects. Any perſon may obſerve a ſalt adhering to the lime of old walls; this ſalt is not in the lime, it is produced by the air. The ſame ſalt is produced by acids. Other experiments might be mentioned, but theſe are ſufficient.

Dung promotes vegetation, by communicating to the ſoil a power of attracting the vegetable food from the air. The earth which it contains is of the abſorbent kind, and attracts all the other principles of the vegetable food; and the ſalts which it contains and produces, attract oils.

It likewiſe promotes vegetation, by preparing the vegetable food for the nouriſhment of plants. By the ſalts which it contains and produces, it not only attracts oils, but alſo diſſolves them, and makes them capable of being mixed with water. It is probable, that oil is a principal part of the food of every plant which we cultivate in our fields, at leaſt is the ingredient of which it is eaſieſt to exhauſt the ſoil, and which it is moſt difficult to reſtore to it again. In proportion to the quantity of oil contained in any plant, in proportion it robs the ſoil, by which it is nouriſhed, of its vegetable food. But the nature of oil muſt be changed before it can enter the roots of plants. This change is made by ſalts; they diſſolve it, and make it to mix with water.

Though dung promotes vegetation in all theſe ways mentioned; yet, as there are other bodies that are much ſtronger attractors of acids, by which many of its effects are produced, it is probable that it principally operates by increaſing the food of plants. Its effects in diſſolving the vegetable food in the ſoil muſt be very trifling. The ſalts which it contains and produces, having its own oils to work upon, and being along with them conveyed into the roots of plants, cannot operate with any violence upon the oils which the ſoil contains. This is confirmed by experience. When the virtues of dung are exhauſted, the ſoil is no poorer than before it was laid on.

Some new improvers are pleaſed to ridicule the old farmers, becauſe they are ſo fond of dung; but none will do this who attentively conſider the virtues of it. Such manures as can be obtained, are to be uſed; and tillage is carefully to be attended to: but this muſt not ſuperſede the uſe of dung, which can be employed to ſo great advantage.

The author of the new ſyſtem of agriculture takes upon him to aſſert, that dung deſtroys ſome land; and that it is as great folly to apply dung to land that requires cooling, as to adminiſter poiſon to a man in a fever. He tells the farmers that they miſs a crop by dunging an improper ſoil, and lay on more dung to remedy the misfortune. Theſe aſſertions may impoſe upon a man that is fond of novelty and paradox; but, with men of ſenſe and experience, they muſt bring into diſcredit every thing that ſuch an author aſſerts.

Though dung in general has all the qualities mentioned, yet there are ſome kinds of it poſſeſſed of ſome of theſe qualities in a higher degree than others. There are as many kinds of dung as there are of animals; and in ſome reſpects they all differ one from another.

The difference betwixt one kind of dung and another, is commonly ſuppoſed to ariſe from the different food of the animals. Green herbage, ſtraw, or hay, do not contain ſo much vegetable food in the ſame quantity as grain does. Hence it is ſuppoſed, that the dung of cows is not ſo rich as that of horſes, nor the dung of horſes ſo rich as that of fowls.

But this difference muſt partly ariſe likewiſe from the nature of the animals, if it be true, that the dung of horſes, cows, ſheep, hogs, and geeſe, all differ one from another, though fed upon the ſame paſture. Some animals digeſt their food more quickly than others. This makes a difference in the dung produced by the ſame food. Some things are digeſted and turned into a ſtate of corruption by ſome animals, that paſs through others ſound and undiſſolved. The matter then in the ſtomach that digeſts the food, muſt be different in the different animals. The dung muſt partake ſomething of the nature of this, which makes another difference in the dung produced by the ſame food.

Some writers on agriculture treat of the dung of the different animals ſeparately. But it is needleſs to do this; for it requires more pains and expence to keep them ſeparate, and uſe each of them by itſelf, than all the advantages ariſing from this way, above the ordinary way, can poſſibly amount to.

The dung of fowls, particularly of pigeons, is an exception to this. It is commonly uſed without any mixture, and it can be kept ſeparate from other dung without any trouble or expence. It is obſerved, with reſpect to it, that the effects of it are more violent, and ſooner over than the effects of common dung. The effects of ſome other kinds of dung would perhaps be the ſame, if they were uſed without any mixture. The pigeons' dung, being thoroughly corrupted, ſoon diſſolves, and becomes vegetable food. But the ſtraw, with which the other kinds of dung are commonly mixed, not being ſo thoroughly corrupted, prevents the effects of them from being ſo violent, and ſo ſoon over.

The way in which pigeons' dung operates, points out the manner in which it ſhould be applied. As it is very rich, and its qualities ſoon exhauſted, a very ſmall quantity ſhould be applied, in proportion to the quantity of other dung. If care be not taken of this, the crop will be deſtroyed by being too luxuriant. Perhaps mixing it with ſome other things may have good effects. The ſtrewing ſmall chaff of any kind, from time to time, on the bottom of the pigeon-houſe, is very proper. The chaff ſucks up the moiſture, and makes it eaſy to reduce the dung to powder, which is an advantage; for thereby the dung is ſcattered more equally, and manures a greater quantity of land.

It is a cuſtom, in ſome places, to fold ſheep and cattle for the ſake of their dung; which, in this way, is uſed without any mixture. Some writers on huſbandry give particular directions how to do this in the moſt advantageous manner But it is needleſs to conſider theſe. The farmer muſt conſult the advantage of his ſheep and cattle, and not the advantage of the land by the dung; and therefore muſt fold them in the moſt convenient manner. A ſcore of ſheep, with the beſt management in folding, will not produce much more than ten ſhillings worth of dung, in the ſeaſon, above the expence of folding; a ſum ſoon loſt by an injudicious management of them.

ESSAY XIX.

On Top-dreſſings.

SOOT, malt-duſt, pigeons' dung, and rape-duſt are conſidered as top-dreſſings. They are never worked into the land by the plow. In that they eſſentially differ from other manures. The theory of top-dreſſings is not generally known: the practice, conſequently, is but imperfectly underſtood.

When any kind of manure is worked in by the plow, we mean to lighten the ſoil, and at the ſame time to fill it with nouriſhing particles. But, when we apply top-dreſſings, we only conſider the nouriſhment of the plants, having no regard to looſening the earth. Light, ſandy, and lime-ſtone lands are beſt managed by top-dreſſings. Stiff loams and clays require lime and rotten dung to break the coheſion of their parts. The one remains in the ground for the benefit of ſucceeding crops; the other is only the food of the year. The tillage-farmer, whoſe ſoil is thin, ſhould pay a careful attention to top-dreſſings. They are the ſoul of his huſbandry. On the lime-ſtone lands in

Yorkſhire, rape-duſt is chiefly uſed; but the price is ſo much advanced, that the farmer can hardly afford to purchaſe it. An acre of wheat land cannot be well dreſſed with leſs than four quarters of rape-duſt: three quarters are ſufficient for an acre of barley. The price is about fourteen ſhillings per quarter. To obviate this great expence, I ſhall recommend a compoſt made of ſhambles blood and ſaw-duſt, which I have found experimentally to equal, if not excel, moſt hand-dreſſings. This compoſt has the peculiar property of being no way offenſive to the ſmell. It comes cheap, and may be procured in every large town. I cannot give any directions relative to the quantity neceſſary for dreſſing an acre of land. My experience upon it has been confined to a ſmall ſcale. It is ſpeedy in its effects, but not laſting.

In Flanders, where manures are well underſtood, they dry and powder human ordure, which they uſe as a top-dreſſing, and find it of a rich quality. In large manufactories, and in places where a number of people live together, it may be a judicious practice to receive all excrementitious matters upon ſaw-duſt, which, by frequently turning over, may be converted into one of the richeſt dreſſings.

In order to have a diſtinct idea of top-dreſſings, we muſt reflect that wheat, oats, barley, and rye have two kinds of roots. The one is called the *ſeminal*, the other the *coronal* root. The firſt lies deep in the ground, and proceeds immediately from the grain: the other is formed juſt within the ſurface. In proportion to the vigour of this laſt, the crown becomes ſtronger or weaker; or, in other words, the plant tillers more or leſs. In winter corn, the plant is nouriſhed, during the ſevere months, by the *ſeminal* root only. It ſhould therefore be placed pretty deep, to ſecure it againſt the effects of the froſt. On this account drill-wheat ſtands the winter better than the broadcaſt. The *coronal* root ſeldom appears before the beginning of March. This is therefore the ſeaſon for the application of top-dreſſings. The firſt ſhower of rain waſhes them juſt within the ſurface, where they become the immediate nouriſhment of the *coronal* root.

In moſt places rape-duſt is harrowed in with the winter corn; but ſoot is always laid on in the ſpring. By the application of this laſt, the plants ſoon recover the injuries of the winter, and a large crown is formed, from which a number of ſtalks are produced in proportion to the ſize of the crown.

In ſpring corn, the *coronal* roots form themſelves within a few weeks after ſowing; for which reaſon the top-dreſſings are always harrowed in with the grain.

It will be neceſſary to remark that, as top-dreſſings can only operate but a little way within the ſurface, they are therefore only proper for horizontal feeders, as wheat, oats, barley, and rye. Beans, and tap-rooted plants, require ſuch manures as are worked into the land by the action of the plow.

It may be objected that turnips, though tap-rooted, yet receive benefit from top-dreſſings; but it muſt be conſidered that they operate upon the plant by puſhing it haſtily into rough leaf, and thereby ſecuring it againſt the fly. After this the turnip flouriſhes or declines in proportion to the richneſs or poverty of the ſoil.

So much depends upon the right uſe of manures, that we cannot employ too much time in inveſtigating their natures. Notwithſtanding what Mr. Tull and other ingenious gentlemen have advanced, I am clearly of opinion that manures are the life and ſoul of huſbandry. Till the farmer can ſcientifically explain the manner that manures operate, he will find it impoſſible to reduce his profeſſion to the ſtandard of reaſon. I therefore flatter myſelf, that, from theſe eſſays, he will be able to collect ſome hints that will be of uſe to him in forming a juſt notion of one of the moſt important branches of agriculture.

BOOK II.

ESSAY I.

On the different Quantities of Rain which fall at different Heights over the ſame Spot of Ground.

EVERY operation of nature which influences vegetation, is intereſting to the ſpeculative and philoſophical farmer. The diſcharge of the Electrical Fluid, by the deſcent of rain, may be conſidered as a primary agent in producing the germination of ſeeds, and the riſing of the ſap in vegetables. Electricity accelerates the motion of the fluids in the capillary tubes of plants, increaſes their perſpiration, heightens their verdure, and powerfully promotes their growth. Hence perhaps, in ſome degree, ariſes the *inſtantaneous* vivifying effect of a ſummer ſhower on the vegetable creation.

It is hoped, therefore, that the following attempt to account for the different quantities of rain which fall at different heights over the ſame ſpot of ground, will not be deemed entirely foreign to the purpoſe of theſe eſſays.

In the laſt volume of the Philoſophical Tranſactions ſome experiments are related, by which it appears, that there fell below the top of a houſe, above a fifth part more rain than what fell in the ſame ſpace above the top of the ſame houſe; and that there fell upon Weſtminſter-Abbey not above one half of what was found to fall, in the ſame ſpace, below the tops of the houſes *. Theſe obſervations, however

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* I am informed by an ingenious correſpondent at Bath, that ſimilar experiments have been made in that place with the ſame reſult; and a friend of mine at Liverpool, on whoſe judgment and accuracy I can rely with confidence, has lately favoured me with the following account, dated March 14, 1771: " During the late rains I repeated Dr. Heberden's experiment: The upper veſſel received thirteen ounces and a half of rain, the lower veſſel twenty-ſeven ounces. The difference of altitude was about ſixteen or ſeventeen yards. The wind blew a briſk gale from the ſouth-eaſt.—I made the trial alſo during a fall of ſnow; and, in that, found the proportion as three to five." The following experiment, communicated to me by the ſame gentleman, varies a little in its reſult from the former, owing, perhaps, to a difference in the ſerenity of the air: for the wind has a more powerful effect on the deſcent of ſnow than of rain, becauſe its ſpecific gravity is leſs. " March 27, 1771, there was a continued fall of ſnow, from eight in the morning till five in the afternoon. The air was ſtill; the ſnow came down very thick, and in large flakes. During the nine hours which the ſnow continued

ever new and ſingular, are too well authenticated to admit of the leaſt degree of doubt; and philoſophy ſhould be employed not to invalidate a fact ſo fully aſcertained, but to furniſh a rational and adequate cauſe of it.

Dr. Heberden conjectures that this phænomenon depends on ſome property of electricity, which he thinks remains hitherto unknown. To me it appears probable, that the common laws by which this power influences the aſcent and ſuſpenſion of vapours, are ſufficient to explain their precipitation in rain, and the lately-diſcovered mode of its deſcent.

The electrical fluid is ſtrongly attracted by water, and by deſtroying the coheſion between

tinued to fall, the upper veſſel received thirteen ounces, the lower veſſel twenty-ſix ounces." In the years 1773 and 1774, the obſervations on the different quantities of rain, which fall at different heights, were repeatedly made at Liverpool: and it was almoſt invariably found, that a veſſel, ſtanding on the ſurface of the ground in a ſpacious garden, received *double* the quantity of rain which fell into another veſſel of equal dimenſions, placed near the ſame ſpot, but eighteen yards higher. At Middlewich, during part of the year 1774, the quantity of rain caught at the top of the church-ſteeple was 15,75 inches; and in a garden, eighty feet below, 19 inches.—The garden, it ſhould be remarked, was not contiguous to, although at no great diſtance from the church.

its particles, and repelling them from each other, it becomes a powerful agent in evaporation. The waters of the ocean abound in this fire, and vapours raiſed from them float in the air, forming clouds which retain their electricity, till they meet with other bodies, either deſtitute of it, or containing it in a leſs proportion than themſelves *. This, in all probability, is frequently the caſe with thoſe vapours or clouds which are produced by exhalations from the earth, from freſh water, and the perſpiration of plants and trees; at leaſt it is an undoubted fact, that ſome clouds (to uſe the language of this branch of philoſophy) are electrified poſitively, and others negatively. No ſooner does the communication take place, but the repulſion between the particles of water is diminiſhed, thoſe which have diſcharged part of their electricity, are ſucceſſively attracted by the contiguous ones which have not; and thus they preſs nearer together, become ſpecifically heavier than the atmoſphere, and deſcend in ſmall drops, which, loſing every inſtant more and more of the electric fire, coaleſce, uniting into larger and larger drops, and conſequently filling a ſpace which is continually diminiſhing, as they approach nearer to the ſurface

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* Vid. Franklin on Electricity.

ſurface of the earth. This may be illuſtrated by electrifying the ſtream of a fountain, which will ſpread itſelf into the form of a bruſh by the mutual receſſion of the particles of water: but withdraw the ſupply of electric fire, and the fountain diſcharges itſelf in one continued current *. A pair of cork-balls ſuſpended together by ſilken threads, when electrified, recede from each other; and if the air be dry, return by degrees only to their natural poſition. Two feathers electrified will float in the atmoſphere, mutually repelling each other, when in a certain degree of contiguity, and gradually deſcending as they loſe that power, which, by expanding their *plumulæ*, rendered them ſpecifically lighter than the air. But if one of them diſcharges ſuddenly the electric fire, it will inſtantly be attracted towards the other, and receive a freſh ſupply; when a repulſion (acting indeed at a much leſs diſtance than before) will again take place between them.

When two clouds, one replete with electric fire, the other deſtitute of it, come within the ſphere of each other's attraction, they will ruſh together, and the electrical fluid being diffuſed

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* Vide Franklin on Electricity.

through a larger ſpace, the particles of water will unite, and form themſelves into drops of greater magnitude, and a heavy ſhower will be produced. Still, however, as the rain deſcends through an atmoſphere containing little electric fire, it will be continually communicating it; and the diſcharge being greateſt from the circumference of the cloud, becauſe the ſurface is there largeſt, the drops will be drawn nearer and nearer to each other, and, approaching towards one common center, will gradually coaleſce in their paſſage. Dr. Franklin has related a moſt ingenious experiment, which elucidates the formation of rain as thus deſcribed. Take two round pieces of paſteboard of two inches diameter; from the center and circumference of each of them ſuſpend, by fine ſilk threads eighteen inches long, ſeven ſmall balls of wood, or ſeven peaſe equal in bigneſs, ſo will the balls, appending to each paſteboard, form equal equilateral triangles, one ball being in the center, and ſix at equal diſtances from that, and from each other; and thus they repreſent particles of air. Dip both ſets in water, and ſome adhering to each ball, they will repreſent air loaded. Dexterouſly electrify one ſet, and its balls will repel each other to a greater diſtance, enlarging the triangles.

angles. Could the water, ſupported by the ſeven balls, come into contact, it would form a drop or drops ſo heavy as to break the coheſion it had with the balls, and ſo fall. Let the two ſets then repreſent two clouds, the one a ſea cloud electrified, the other a land cloud; bring them within the ſphere of attraction, and they will draw towards each other, and you will ſee the ſeparated balls cloſe thus: the firſt electrified ball that comes near an unelectrified ball, by attraction joins it, and gives it fire; inſtantly they ſeparate, and each flies to another ball of its own party, one to give, the other to receive fire, and ſo it proceeds thro' both ſets, but ſo quick as to be in a manner inſtantaneous. In their colliſion they ſhake off and drop their water, which repreſents rain. This experiment would better illuſtrate and confirm my *hypotheſis*, if a larger number of balls were appended at equal diſtances, to each paſteboard, ſo as to form ſeveral circles, having one common center.

But it rarely happens that a land cloud is equal in magnitude to one raiſed from the ſea, conſequently the rain produced by their union will be proportionably lighter in the upper, and heavier in the lower regions of the atmoſphere.

ſphere, as the electric matter is more or leſs gradually diffuſed.

When an electrified cloud, without mixing with another cloud, or loſing part of its electric fire, becomes ſpecifically heavier than the atmoſphere, by cold, or ſome local change in the denſity of the air, it will deſcend at firſt perhaps in a miſt; but will form, as it approaches nearer to the earth, and is leſs replete with the electric fluid, a light ſhower of rain.

Beſides the clouds which float ſeparately in the higher regions of the atmoſphere, the air contains a large quantity of water in the ſtate both of ſolution and of diffuſion; and dews, fogs, and ſometimes even ſhowers of rain, are probably produced by the precipitation of the water thus ſuſpended. Now the quantity of water which the air is capable of diſſolving and ſuſpending, is proportioned to its degree of denſity; and this denſity decreaſes in a certain ratio, according to its diſtance from the ſurface of the earth. Rain, therefore, in its deſcent will be every inſtant acquiring an acceſſion to the bulk of its drops, by attracting theſe aqueous vapours. For the cold produced by a falling ſhower, will precipitate from the air, both its diſſolved and diffuſed water. And thus, at different heights, will be produced, from this cauſe, ſome difference in the quantity of rain which falls over the ſame ſpot of ground. The diſcharge of the electrical fluid from a falling ſhower, may alſo act as a powerful precipitant of the vapours, which are chemically diſſolved in the air. For by conveying an electrified wire to the ſurface of a quantity of water, ſaturated with any ſaline ſubſtance, an immediate and copious precipitation is produced, and the ſalt forms itſelf into large *flocculi*.

Rain, when undiſturbed by winds, deſcends in lines converging towards the center of the earth, like the *radii* of a circle. This direction towards the perpendicular, however trifling in degree, gives ſome little tendency to the drops to coaleſce together, and concurs in the general effect of producing a different quantity of rain at different heights.

From what has been advanced, it appears probable to me, that the gradual diſcharge of the electrical fire is the principal cauſe of the phænomenon I have attempted to explain. As the rain deſcends, the drops coaleſce more and more together, by the continued diminution of the repulſive power which counteracted their mutual attraction; and conſequently, in a given ſpace, a much larger quantity will fall near to, than at a diſtance from, the ſurface of the earth. A cloud which fills many thouſand acres in the higher regions of the air, when the electric fluid operates upon it with full force, may not cover one third of that extent when it has deſcended in a ſhower of rain. To this effect the precipitation of the vapours contained in a diſſolved or diffuſed ſtate, in the lower regions of the atmoſphere, and the influence of gravitation in producing a convergency of the drops of rain, will in ſome degree contribute.

P. S. Having communicated the preceding paper to Dr. Heberden and Dr. Watſon, I have been favoured by the latter with the following curious fact.—"The water in the rain-gage at the top of Lord Charles Cavendiſh and Dr. Heberden's houſes, which are about a mile diſtant from each other, pretty nearly correſpond; but at the bottom of Lord Charles's houſe, though the level is forty feet above the top of Dr. Heberden's, the quantity always exceeds that of Dr. Heberden's. Laſt year, for inſtance, at the top of both their houſes, there were collected about twenty-two inches of rain; but in Lord Charles's garden, at a diſtance from any buildings, there fell twenty-ſix inches; and this, in his Lordſhip's garden, has been conſtant for ſeveral years. Dr. Heberden has been too much confined to make accurate obſervations at the bottom of his late houſe; but he is now removed to Pall-Mall, where his opportunities of obſerving are more favourable."

This fact, at firſt ſight, appears to be a ſtrong objection to the *hypotheſis* I have advanced. May it not, however, be obviated, by ſuppoſing that the diſcharge of the electrical fluid from a falling ſhower, is not ſo much influenced by the abſolute, as by the relative height of the places where the rain deſcends? And as the earth may be conſidered as the great recipient and attractor of electrical fire, is it not probable that the quantity of rain collected will be proportioned to the diſtance of the receiver from the ground immediately below, and not to its abſolute height, meaſured from any diſtant level, except in ſuch altitudes where the denſity of the air, and the vapours floating in it, are ſo far diminiſhed as to produce a ſenſible variation? But I offer this conjecture with diffidence; and am ſenſible indeed that the whole of my attempt to account for the different quantities of rain, which fall at different heights, is liable to objections, becauſe the *data* are yet few upon which it is founded. To promote the ſolution of ſo curious a phænomenon, I ſhall here ſubjoin a few queries, propoſed to me by different correſpondents. The fourth ſhould, I apprehend, be reverſed, becauſe it appears probable to me, that trees, plants, water, and moiſt earth, afford more copious exhalations than paved ſtreets, houſes, burning fuel, or the bodies of men.

1. Does a glaſs funnel catch an equal quantity of rain, at the ſame height, as a metal funnel; the former being an electric, the latter a non-electric? [*].

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[*] A very ingenious friend of mine, at Cheſter, has lately favoured me with the following experiments, which furniſh a ſatisfactory anſwer to this query, and at the ſame time confirm the hypotheſis I have advanced, by proving that rain contains, and diſcharges in its deſcent, the electrical fluid. Two veſſels of equal diameters, the one of glaſs, the other of tin, placed at the ſame height, and within a foot of each other, varied as follows in the quantities of rain which they received: From April 15, 1771, to 29, the glaſs veſſel received 0.954, the tin veſſel received 1.432. From May 5, to 30, the glaſs veſſel received 1.630,

2. Is there a difference in the quantity of rain and ſnow catched in ſimilar veſſels at different heights?

3. Is the difference of rain, catched at different heights, greateſt at the beginning of a ſhower?

4. Is not this difference greater in large cities than in the country, owing to the lower regions of the air being more loaded with watery vapours,

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1.630, the tin veſſel received 2.027. From June 1, to 28, the glaſs veſſel received 2.144, the tin veſſel received 3.674.

The ſame accurate obſerver found that in the months of June and July, 1771, contrary to the common courſe of nature, a larger quantity of rain was received in the higher, than in the lower funnel. For inſtance, the rain caught in a veſſel placed at the top of St. John's ſteeple, from June 2, to July 1, amounted to 1.886, and from July 2, to Auguſt 3, to 1.423. Whereas a ſimilar veſſel, placed in a garden below, received, during the ſame ſpace of time, only 1.404, and 0.452. This inverſe proportion of rain, received at different heights, cannot be ſuppoſed to depend either upon chemical or mechanical principles, but may be accounted for by the ſame electrical laws, which have been adduced to explain the more uſual phænomena of its deſcent. If the falling ſhowers proceeded from clouds negatively electrified, the drops of rain would diverge more and more as they approached nearer to the earth, becauſe, inſtead of communicating, they would receive ſome portion of electricity from the vapours floating in the lower regions of the atmoſphere.

vapours, which have been exhaled by fires, and from the human body?

5. Has the wind no ſhare in producing the diſparity obſerved in the quantities of rain which fall at different heights?

6. May not the column of air, through which a drop of rain paſſes, in the ſpace of twenty or thirty yards, contain a ſufficient quantity of watery particles to double the bulk of the drop? This may be illuſtrated by precipitating any ſaline ſubſtance from a ſaturated ſolution of it, contained in a cylindrical veſſel, and examining the proportional quantities of precipitate at different heights. Or, perhaps, it may be determined by the following experiment: Take a cylindrical glaſs veſſel, four inches in diameter, and eight inches high; fill it with ice or ſnow, and place it in a warm room. A watery dew will ſoon be congealed upon its ſurface, which being committed to a nice ſcale, may probably be found to be equal in gravity to a drop of rain. Suppoſe this cylinder to be drawn out to the length of twenty or thirty yards, the ſurface of it will ſtill continue nearly the ſame, though the diameter of it be diminiſhed; and ſuch a tube will aptly repre-

ſent the column of air through which a drop of rain deſcends in its paſſage to the earth.

ESSAY II.

On the Culture of Potatoes.

THE potatoe plant was firſt brought from America into Ireland by Sir Walter Raleigh. Though a ſpecies of the *Solanum*, or Night-ſhade, yet experience has moſt fully convinced us, that it is one of the beſt and moſt nutritious of all the eſculent roots cultivated in this iſland. The great uſe and advantage of this vegetable, as a food, was never more happily experienced than four years ago, when an extraordinary crop *, both in quantity and quality, reduced the high prices of grain ſo much in this very populous neighbourhood †, as to give the poor an opportunity of buying bread upon more reaſonable terms than it was to be had in many of the moſt conſiderable corn counties of the kingdom. I therefore flatter myſelf that it may be of uſe to point out the beſt methods that have occurred to me, not only of obtaining a large and good crop, but alſo of preparing the ground at the ſame time, and in the beſt manner, for a ſucceeding one of wheat. An object of no ſmall importance to the farmer.

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* From an acre and a half, ſtatute meaſure, I had as many potatoes as ſold (at the low price of 1 s. 3 d. per buſhel) for near 34 l. beſides ſerving my own family (in which large quantities are conſumed) and reſerving a ſufficient quantity for planting near two acres the year following,

† Rochdale.

In the firſt place, I ſhall mention the kind of ſoil that is the beſt and moſt proper for the culture of this excellent root. The potatoe plant will indeed grow in almoſt any ſoil; but the mere growth of the plant, or the poor return of a few ſmall and inſipid roots, are not worthy the care and attention of the farmer.

The ſoil which I would prefer above all others, for this plant, is the ſame which Columella recommends for vines: *Nec ſpiſſum ſit nimis, nec reſolutum, propius tamen reſoluto; nec exile nec lætiſſimum, tamen læto proximum; nec campeſtre nec præceps, ſed potius edito campo; nec ſiccum nec nimis uliginoſum:* that is, the ſoil ſhould neither be too ſtiff and untractable, nor too light and crumbling, yet rather of the crumbling

bling

ling kind; neither too poor nor too rich; yet inclining to richneſs; neither too flat nor too hilly, but rather gently riſing; neither quite dry nor yet ſurcharged with moiſture. With ſuch a ſoil, and proper management, a noble return may be expected; and the nearer any ſoil approaches to the nature and qualities above recommended, the more proper and ſuitable it will be for the cultivation of the potatoe plant. But even from ſoils, not bleſſed with all thoſe deſirable qualities, very beneficial crops may be obtained, if a little more labour and pains are beſtowed upon the neceſſary operations.

The different ways of preparing the ground for this crop (which are either by plowing, trenching, or common digging) are ſo well known in all, or moſt parts of the iſland, that it would be uſeleſs, as well as impertinent in me, to give any directions on that head. I will only give it as my opinion (founded on ſome experience) that when the ground, intended for a potatoe crop, is not of any great extent, trenching (though the moſt expenſive) is far preferable to the others, and will generally more than repay the additional expence. I will venture alſo to condemn the common Iriſh way of planting, which is known and uſed in ſome parts of the kingdom, and is properly denominated the lazy-bed way. In this method the eyes or ſets are placed upon the ſurface of the ground, with a little dung under them, and then a deep trench is made on each ſide, with the earth of which the ſets are covered. By this horrid practice a barren, and perhaps noxious under-ſtratum of earth or rubble is thrown up ſo high as never to get covered again, but remains there as a woeful exchange for ſome of the fineſt mould, that is buried beneath the reach of the plow.

I ſhall now endeavour to point out the beſt method of planting the ſets, both for the preſent crop, and alſo for a due preparation of the ground for a ſucceeding one of wheat.

The ſets (with one good eye, or two at moſt) ſhould be planted in rows two feet aſunder at leaſt, if the crop is intended to be cleaned with the hand-hoe, and at the diſtance of fifteen or ſixteen inches from each other in the rows; after which the ground ſhould be broke in with a rake or light harrow. After the plants are come up, the firſt growth of the weeds ſhould be carefully obſerved; and, taking

king the advantage of a dry and hot ſeaſon, ſhould be cut down, both betwixt and in the rows, and the earth hoed up a little towards the roots of the plants. The weeds being checked in their firſt ſhoot, and in ſuch weather, will be long before they make any conſiderable head again. About midſummer it will be neceſſary to go over the ground once more with the hoe; and if the advantage of a dry and hot ſeaſon can then be taken, it will generally be ſufficient to keep the land clean and free from weeds for the remainder of the ſummer, as the plants will then be grown ſo ſtrong and buſhy, as nearly to cover the whole ſurface of the ground; and therefore, by their ſhade and dropping, will prevent any future growth of weeds.

Theſe ſtirrings by the hoe will keep the land in proper tilth, and kindly diſpoſe it to receive the benign influence of the ſun, air, and dews; and the intervals betwixt the rows of the plants will alſo allow due admiſſion to the air, ſo abſolutely neceſſary for vegetation. "The air," as Biſhop Berkley obſerves in his Siris, "is the receptacle as well as ſource of all "ſublunary forms, the great maſs or chaos "which imparts and receives them. The at-

“ moſphere which ſurrounds our earth, con-
“ tains a mixture of all the active volatile parts
“ of all vegetables, minerals, and animals.
“ Whatever perſpires, corrupts, or exhales,
“ impregnates the air; which, being acted
“ upon by the ſolar fire, (here is literally *con-*
“ *jugis in gremium lætæ deſcendit)* produceth
“ within itſelf all ſorts of chemical operations,
“ diſpenſing again thoſe ſalts and ſpirits, in
“ new generations, which it had received from
“ putrefactions. The air, therefore, is an ac-
“ tive maſs, compoſed of numberleſs diffe-
“ rent principles, the general ſource of corrup-
“ tion and generation, in which the ſeeds of
“ things ſeem to be latent, ready to appear and
“ produce their own kind whenever they light
“ upon a proper matrix. The whole atmo-
“ ſphere ſeems alive; there is every where acid
“ to corrode, and ſeed to engender, in that
“ common ſeminary and receptacle of all vivi-
“ fying principles.”

That the free admiſſion and circulation of air, are not only conducive, but alſo abſolutely neceſſary to a ſpeedy and vigorous growth of plants, might be eaſily proved by many experiments; but it is too obvious to every one, who has taken the leaſt notice of the operations of nature in the important work of vegetation, to need ſuch proofs of its neceſſary influence. Without ſome air, it is well known, vegetation would neither begin nor continue. Dr. Fordyce, in his Elements of agriculture and vegetation, ſays, That even roots require air; ſo that if a root is planted too deep, it will not grow on that account. He is of opinion alſo, that light is neceſſary for the growth of a plant, but not ſo much as air.

Many growers of potatoes, from want of experience, are apt to imagine that the greater number of plants they have, the greater will be the increaſe. In regard to numbers it poſſibly may be ſo, but even that admits of a doubt. The true proof of the increaſe, or return, is in the weight and goodneſs of the crop, and not merely in the number of pitiful roots. In the common promiſcuous and cloſe way of planting, the ſtems of the plants are drawn up ſo nigh and ſlender, by their contiguity to each other, that they become weak and languid long before the proper time of perfecting their roots; a certain indication of a miſerable crop.

The ground, as is obſerved by Mr. Tull, (to whom, not only his own country, but many others in Europe are ſo much obliged for laying a rational foundation for moſt of the modern improvements in huſbandry) contains a certain quantity of *pabulum*, or food for vegetables, which, though it may be conſiderably increaſed by manures, has its ſtated bounds, its *ne plus ultra.* The ſame gentleman mentions an experiment that he made, which very fully proves the great advantage of planting the potatoe-ſets at a conſiderable diſtance from each other, and alſo the very great utility of hoeing and ſtirring the ſoil well about them. "A piece of ground," ſays he, "was planted with potatoes, the greater part in the common way; but in one part (worſe than the reſt) they had been ſet at a yard diſtant every way; the reſt of the ground was dunged; this poor part had no dung, but was plowed four times in different ways, ſo that the ground was broken and ſtirred thoroughly every way about the potatoes. The conſequence was, that though no dung was uſed here, and the plants appeared ſhorter than in the dunged part, yet the crop was greatly better than in the other part of the field. The roots here were all large; in the other part which was dunged, and planted in the common way, and alſo without ſuch plowing, they were ſo ſmall, that the crop was ſcarce worth taking up."

Where great quantities are planted, hoeing with a ſmall light plow will be neceſſary for diſpatch, and will do very well, and in ſome reſpects better than hand-hoeing, as the ground will be more effectually ſtirred; but the weeds ſhould be cleared at leaſt once with the hand betwixt the plants in the rows; and care ſhould be taken not to throw too great a quantity of earth upon the roots, as that would be almoſt fatal to the potatoes in every reſpect, but eſpecially in the goodneſs of them. The plants in a healthy vigorous ſtate will, by the *umbrageous* defence of their thick leaves and ſtems, ſufficiently protect the roots from the too ſcorching rays of the ſun, and even retain a due degree of moiſture in the ground, without excluding ſo much of his *energetic* power as is neceſſary for perfecting the great work of vegetation: but, if the roots are buried too deep, that cheering and vivifying power of the ſun is ſo impeded in exerting its neceſſary influence, that the roots never arrive at their utmoſt ſtate of perfection.

If the potatoe-crop is intended to be dreſſed both with the plow and the hand-hoe, two rows ſhould be planted about the diſtance of eighteen inches from each other; but the intervals, or ſpaces betwixt each double row, ſhould be at leaſt four feet, or there will not be room enough for the plow to work, without injuring the ſtems of the plants. If the crop is to be cultivated with the hoe-plow only, then ſingle rows are beſt, leaving a ſpace, as above, of four feet at leaſt betwixt every row. This is a very expeditious way of cleaning a crop, and will anſwer all the purpoſes of hoeing very well. The way of planting the ſets for this laſt kind of cultivation is very expeditious, and is as follows:

The ground being laid level, and in fine tilth, a ſtraight furrow muſt be made from one end of the field to the other, leaving a ſpace of two feet wide betwixt it and the verge, or border of the plowed land. A boy follows after the plow, with the ſets in a baſket, and drops one at every fifteen or ſixteen inches. When that is done, the plowman turns about, and throws the furrow back again upon the ſets, then begins with another furrow, leaving the proper ſpace betwixt, returns again as before, ſore, and ſo on till the whole piece of ground is finiſhed. One man, with a plow and two horſes, and two boys, (one to keep the horſes in a ſtraight line, and the other to drop in the ſets) will finiſh a large quantity of land in a day. When the whole planting is finiſhed, the ground ſhould be levelled by harrowing acroſs.

This is the beſt method for dry land; but if the ground be moiſt, ſtrong, or heavy, it ſhould be thrown into ridges of four or five feet each, and the ſets planted on the top of the ridges. The depth of the furrows alſo ſhould vary according to the nature of the ſoil. If it be very dry and light, the furrows may be made five inches deep; if moiſt, heavy, or ſtrong, not above three or four at the moſt.

Having given directions about the management of the crop, I ſhall now beg leave to offer my ſentiments in regard to the beſt kinds of potatoes now cultivated in this neighbourhood, both for ſummer and winter uſe. For the former, I would recommend the early red and white dwarfs, and the flat white kidney, by ſome called the true Spaniſh potatoe: For the latter, the white ruſſet, the red ruſſet, the golden tag, the Iriſh dun, and the ſmooth winter white. Indeed, for black earth, the Iriſh blue potatoe, and the old Engliſh reds, are the moſt proper, as they are very hardy, and have ſtrong coats or ſkins, which make them bear moiſture better than the other kinds. The white Lincolnſhire potatoe grows very large, and is a moſt plentiful bearer; it is alſo well flavoured, though not equal to ſome above-mentioned. But the moſt extraordinary potatoe of all, for producing great crops, is the Howard or Buckinghamſhire potatoe. Mr. Doſſie ſpeaks of it as a very nutritious and agreeable taſted root, if ſufficiently boiled. Its increaſe almoſt exceeds belief; on which account I ſhall venture to recommend it to the attention of thoſe who plant potatoes as food for cattle and hogs; a practice highly to be approved.

Laſt year I planted four eyes, from one of thoſe potatoes, in four different kinds of ſoil:

N° 1. A ſtrong rich loam.
2. A light rich loam.
3. A good gravelly ſoil.
4. A ſandy ſoil.

The produce:

N° 1.	34 lb.
2.	29
3.	19
4.	15

I ſhall now mention, in as conciſe a manner as poſſible, ſome other experiments I made laſt year, in order to aſcertain what kind of manure is moſt agreeable or beneficial to the potatoe plant.

I had a ſmall field which was laid down in lands of about five feet broad: I put the intended manures into the furrows, and then plowed it in the common way, by which means the manures were thrown into the middle of all the new lands, and upon which I planted the ſets. The rows were all exactly of the ſame length; the very ſame quantity of ſets in each row; and all had the very ſame advantages of hoeing:

N° 1. Manured with coal-aſhes only.
2. Stable-dung and coal-aſhes mixed.
3. Stable-dung alone.
4. No manure.
5. Compoſt made of dung, lime, and ſoil.

N° 6. Stable-dung covered with common yellow moſs.
7. Soaper's waſte.
8. Stable-dung and lime.
9. Lime alone.
10. Coal-aſhes and lime.
11. Stable-dung and ſoaper's waſte.
12. Soot, ſoil, and coal-aſhes.
13. Salt and ſoil.
14. Saw-duſt and coal-aſhes.
15. Stable-dung and ſaw-duſt.
16. Dung of poultry and coal-aſhes.
17. Dung of poultry and ſand.
18. Saw-duſt and lime.
19. Decayed ruſhes and lime.
20. Tanners' bark and lime.
21. Bark and ſtable-dung.
22. Bark alone.
23. Stable-dung with lime ſpread over the land.
24. Chopped whins with a covering of lime over them.

The produce.

N° 1. 211 lb. rather ſmall in ſize.
2. 344 lb. very fine.
3. 315 lb. ditto.
4. 134 lb. very ſmall.

N° 5. 204 lb. middling ſize.
6. 438 lb. remarkably fine.
7. 383 lb. very fine.
8. 268 lb. tolerably well ſized.
9. 187 lb. ditto.
10. 192 lb. ditto.
11. 298 lb. very good ſized.
12. 271 lb. ditto.
13. 200 lb. ditto.
14. 190 lb. ſmaller in ſize.
15. 307 lb. very fine.
16. 236 lb. pretty fine.
17. 156 lb. rather ſmall.
18. 197 lb. ditto.
19. 208 lb. very good ones.
20. 76 lb. very poor ones.
21. 144 lb. rather larger.
22. 35 lb. very poor.
23. 232 lb. pretty fine ones.
24. 256 lb. very fine and large.

I can only ſay in favour of this account, that it is very accurate. I ſaw the potatoes taken up and weighed, and alſo entered them (upon the field where they were weighed) into my memorandum-book, from whence the above account is taken. Many will be ſurprized at the apparent advantages ariſing from the uſe of whins and moſs. The former I had known tried before, and with ſucceſs, in the culture of potatoes; and the latter I found ranked at the head of a claſs, termed the *fattening manures*, in a periodical work, publiſhed at Paris under the title of *Journal Œconomique.*

As ſtable-dung and moſs ſeemed, from the above experiments, to have the advantages over all the reſt, I was determined to make a fair trial of their reſpective merits. Accordingly I had two rows of potatoe-ſets planted alternately upon ſtable-dung and moſs, ſo that there could be no advantage, either from ſoil, expoſure, or cultivation, to one plant more than another. I had one row dug up in my preſence, and immediately weighed. The conſequence was, the crops were ſo equal in weight, that the balance could not determine the difference. Thoſe that came from the dunged plants were more in number, the others better and more equally ſized.

The laſt experiment was made upon ſome ſeedling potatoes, called the *Ogden Seedlings*, raiſed the preceding year from one of the forward kinds. They promiſe much, both for goodneſs and perfecting their roots very early.

All our varieties have been procured from the ſeed, and more may be expected: This is certainly the beſt method to keep our preſent ſorts from degenerating.

This year I took up one row of potatoes, part of which was manured with ſtable-dung and coal-aſhes, the other with the ſame quantity of ſtable-dung and moſs. The conſequence was, that thoſe from the dung and moſs, not only exceeded the others in ſize, but were about a third more in weight. The ſoil and cultivation the ſame.

Many inferences may be deduced from the above experiments, ſome of which are very obvious; as that moſs is a very good manure for potatoes; ſtable-dung very good and proper; coal-aſhes the ſame, but not equal to the former; ſoapers' waſte a very good one, but it is too dear, as well as difficult to be obtained in large quantities.

ESSAY III.

On the Analogy between Plants and Animals.

IN a former eſſay, the laws of vegetation were plainly diſcovered to be analogous to thoſe maintained throughout the animal world. And if we extend our inquiries, we may trace the connection ſo far, that it would be difficult to determine where it ceaſes.

It is amazing to obſerve the infinite wiſdom of the Creator in his works, and the intire dependence which one part of them has upon the other. We, who at beſt can only reaſon from ſecond, and thoſe very imperfect cauſes, muſt neceſſarily ſtand amazed whenever we contemplate the works of the creation.

It is our duty, however, to extend all inquiries, which are ſubſervient to the advantage of ſociety, to the higheſt pitch of perfection in our power. The ſtudy of nature can never be ſufficiently attended to. Nor can agriculture be ever brought to perfection, till a juſt theory be drawn out from the walk of nature herſelf. She is ſo bountiful to us, that her treaſure is never exhauſted, and the more diſcoveries we make, the more we find intirely unknown to us.

It is true the vegetable world is a very paſſive one. The want of ſenſation, and the means of ſelf-preſervation, render it eſſentially different from the animal world. In moſt other points, the image of the one may be diſtinctly traced in the mirror of the other. They have a code of laws drawn up for them by the author of nature himſelf, and to it they ſteadily adhere.

It need ſcarce be remarked, that nature obſerves her ſtages and periods of life, in the vegetable, as well as in the animal world. We obſerve the greateſt tenderneſs and delicacy in the firſt growth of every plant. Their maturity wears every mark of health and vigour: and this is the period for produce and increaſe. Vegetables, as well as animals, afford ſtrong evidences of the decline of life. When nature has run its courſe, we obſerve the brawny oak gradually decay: hoary old age tumbles it into ruins, and *the place thereof knoweth it no more.*

Some plants are of longer duration than others. Annuals, Biennials, Perennials may all be obſerved within a very narrow compaſs of ground. Some produce flowers but once in the time of their exiſtence, and then exhauſt their own life in giving it to their offspring. One revolving ſun often meaſures the duration of other flowers, particularly the Ceres, which, like children, frequently come into the world, as it were, but to try to live.

We certainly may imagine, with great truth, that plants have few offices to perform. And yet nature has aſſigned them more than we are aware of, for our uſe as well as inſtruction. The ſtory of the ſun-flower in Ovid's Metamorphoſes, is confirmed by daily obſervation. Thomſon beautifully deſcribes its affection:

> But one, the lofty follower of the ſun,
> Sad when he ſets, ſhuts up her yellow leaves,
> Drooping all night; and when he warm returns,
> Points her enamour'd boſom to his ray.

Moſt of the diſcous flowers, by ſome elaſtic power unknown to us, follow the ſun in its courſe. They attend him to his evening retreat, and meet his riſing luſtre in the morning with the ſame conſtant and unerring law.

Vegetables enjoy their periods of ſleep and reſt equally with the animal world. The common goat's-beard ſeems deſigned to remind us of the ſun paſſing the meridian, by cloſing up its flowers at that time; whilſt all the trefoils ſerve as a barometer to the huſbandman, by conſtantly contracting their leaves againſt an impending ſtorm. I need ſcarce mention the contracting qualities of the tamarind, acaſia, ſenſitive plant, the common whitlow-graſſes, and cuckoo-bread, to ſtrengthen my aſſertions. They are facts ſufficiently known to mankind in general.

In the animal world we obſerve, that many creatures undergo various changes during the courſe of their exiſtence. The caterpillar, in particular, undergoes ſeveral changes before it produces a butterfly. The very ſame effects may be traced in the vegetable world. Who could imagine, without knowing the fact, that ivy, in its infant ſtate, bears lanceolated leaves, and produces neither flowers nor fruit? In its next ſtate the leaves are quinquelobed, and the plant adheres, in a barren ſtate, to trees and rocks for ſupport. Three years generally elapſe, like a peacock in getting his plumes, before it branches out into a tree, with trilobed leaves, and produces both flowers and fruit. And it is ſtill as wonderful to obſerve, that it finiſhes its growth with plain oval leaves.

Diſeaſes are as incidental to plants as animals. The amputation of a limb, or the loſs of it by the violence of a tempeſt, ſpoils the ſymmetry of the plant, and retards its growth. The vine bleeds too much if it is pruned by an unſkilful hand, or at an improper ſeaſon. The orchard refuſes its crop of apples, if we uſe the knife frequently or improperly. Canker, on another hand, corrodes the very vitals of exiſtence. And nothing is ſo common as to ſee inſects and vermin deſtroy the moſt vigorous ſhoots. Exceſſive drought, or intenſe cold, and, above all, an improper ſoil, ſhoot the arrows of certain death. We readily allow that an inhabitant of the Torrid Zone would ſoon be ſtarved to death in Greenland or Lapland: But we forget that the ſame wiſe Creator of all things, has alſo appropriated a proper ſoil and climate to the ſimpleſt weed that grows.

ESSAY IV.

On Experiments.

EXperiments correctly made, and fairly related, form the data on which agriculture ſhould be founded. To plan an experiment well, to trace it minutely through its progreſs, and to draw a juſt concluſion, is expected from the philoſopher. And yet experiments that ſpring from chance more than reaſon, ſhould not be neglected. The following have been tranſmitted to me. Their authenticity and correctneſs ſufficiently recommend them.

EXPERIMENT I.

On manuring Meadow Lands *.

It is a general practice for the farmers in the ſouthern counties to manure their meadow lands at Chriſtmas. We, on the contrary, put it on as ſoon as poſſible after the ſithe. I have made a number of trials with a view to deter-

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* By Mr. T. Bond, of Heworth, near York.

mine the merit of each reſpective way, and dare venture to ſay that it is better to manure when there is ſome life in the graſs, than at a time when all vegetation is ſtopt.

The ſouthern farmers alledge, that the volatile parts of the dung may, during that hot ſeaſon, be exhaled by the ſun. I grant that this objection may have ſome weight; but it muſt be conſidered that rain frequently falls at that ſeaſon of the year, a ſmall quantity of which will be ſufficient to waſh the dung amongſt the old roots of the graſs, which, by ſhading it from the rays of the ſun, enables it to preſerve its vigour. This effect is the more readily accompliſhed, as we conſtantly employ a heavy buſh-harrow to ſpread the dung equally upon the ground. By following this method, our aftermath generally becomes luxuriant. Beſides, it more effectually encourages the ſhooting of the young graſs in the ſpring. The roots of all perennial graſſes renew themſelves by off-ſets, and die after they have perfected their ſeed. The manure, when laid to the old roots, invigorates the off-ſets, by keeping them warm during the winter. Lands manured after the ſithe are not ſo eaſily frozen as thoſe which have not been dreſſed in that manner. This is an undoubted fact, and proves greatly in favour of the northern huſbandry. After very ſevere winters, the young graſs that ſhould have branched out from the old roots is frequently killed. The ſeeds alſo which were ſhed in July, being young and tender, are often deſtroyed. Our manner of dreſſing affords them a certain protection in the ſevereſt ſeaſons. It may be objected, that dung, laid on after the ſithe, may render the aftermath diſagreeable to the cattle. But our farmers do not practically find that inconvenience. Could we always be ſure of a ſhower of rain within a few days after laying on the manure, our method would then, inconteſtibly, be the beſt; but, even without that certainty, I find it better than the other.

EXPERIMENT II.

On the Oil-Compoſt.

In the month of June I ſelected four lands, of equal goodneſs, in a field intended for turnips. The ſoil was a light ſand, with a tolerable quantity of vegetable earth amongſt it. It was plowed out of ſward in November, and had not borne a crop for many years. I ſhall diſtinguiſh my experimental lands by N° 1. 2. 3. 4.

N° 1. was manured with rotten dung.
2. with oil-compoſt.
3. with lime.
4. was left without any dreſſing.

On the 20th of June they were all ſown with turnip-ſeed, broad-caſt, and during the courſe of the ſeaſon were twice hoed.

In November I viewed the field, and made the following remarks:

N° 1.—the beſt.
2.—the next.
3.—the worſt.
4.—better than N° 3.

Here the oil-compoſt appears in a favourable light; but other trials, made with equal accuracy, ſeem rather to prove that it is not proper for turnips, barley, or quick-growing vegetables. It requires being meliorated by the action of the atmoſphere, and therefore is better adapted to winter crops. I am confirmed in this idea by repeated experiments made ſince the publication of the firſt edition of theſe eſſays.

Upon the above experiments we may remark, that liming of ſandy lands, for turnips, does not encreaſe the prolific virtue of the ſoil, as the land, in a ſtate of nature, bore a better crop than the one that was limed.

When the land happens to be ſtiffer than is required for turnips, it may be good huſbandry to lay upon it a large quantity of lime to open its body for the free admiſſion of the tap-root of the turnip. The lands will alſo be rendered more dry, without which the turnips will never arrive at any ſize. Farmers, in general, take great pains to pulverize their light ſoils intended for turnips; but they ſeldom plow deep enough. A turnip is found to root deep, and in all operations of huſbandry we ſhould be careful to follow the bias of nature. It is for that reaſon we ought to make ourſelves acquainted with the ſize and ſhape of the roots of ſuch plants as are objects of field-huſbandry. When once we have obtained that neceſſary knowledge, it will be an eaſy matter to ſuit the preparation of the ſoil to the nature of the grain. It will alſo enable us to direct the variations of our crops upon juſt and rational principles.

It is abundantly evident that all plants live upon the ſame food. Some require more, ſome leſs. Some take it near the ſurface, others take it deeper. Upon theſe principles we may account for the neceſſity of varying the crops in the old huſbandry. The drill huſbandry makes all changes of ſpecies unneceſſary. In it all kinds of grain may be ſuited to the lands moſt proper for them. The ſucceſs of that ſort of huſbandry, when properly conducted, proves to a demonſtration that all plants are nouriſhed by the ſame food. That food, I apprehend, conſiſts chiefly of oily particles.

It is of great moment to fix upon what is really the nutriment of vegetables, as it will enable us to conduct our compoſt dunghills upon juſt and rational principles. The doctrine of manures is but little underſtood. The farmer ſhould at all times retain in his memory a general idea of them. He may divide manures into four kinds.

1. Such as give nouriſhment only; as rape-duſt, ſoot, malt-duſt, oil-compoſt, blood-compoſt, pigeons' dung, and all hand-dreſſings.

2. Such as give nouriſhment, and add to the ſoil; as horſe dung, cows dung, human ordure, rotten animal and vegetable ſubſtances.

3. Such as open the ſoil, and do not nouriſh in their own nature; as lime, light marls, ſand, and vegetable aſhes.

4. Such as ſtiffen the ſoil, and at the ſame time nouriſh a little; as clay, clay marls, and earth.

An attention to theſe general remarks, and a few obſervations upon the openneſs, ſtiffneſs, and depth of the different ſoils, will enable the farmer to lay down a rational ſyſtem of cultivation.

The theory of Agriculture being but little underſtood, it is no wonder that the practice has remained, for ages, ſo vague and uncertain.

EXPERIMENT III.

On a new Kind of Manure.

All kinds of animal ſubſtances go into ſpontaneous putrefaction. Vegetables do the ſame;

but to effect their entire diſſolution a greater degree of heat is required. I do not mean in this place to treat of the various manures made uſe of by the farmer. It would be carrying me into a field too extenſive for my limited deſign. The foregoing experiment contains ſome general remarks upon this head, which the intelligent huſbandman may eaſily improve into a ſyſtem.

The bounty granted by parliament for the encouragement of the whale fiſhery, has been the means of ſaving an immenſe ſum to this nation. The Dutch uſed formerly to monopolize the trade; but, by the wiſdom of the legiſlature, we now enjoy a conſiderable ſhare of it. In a former eſſay, I have endeavoured to ſhew that train-oil made into a compoſt with pot-aſh, makes a good ſuccedaneum for dung. A number of experiments, made by very accurate obſervers, ſeem to eſtabliſh the opinion.

When the oil has been taken from the blubber, by the action of boiling water, the remaining part is thrown into the ſea. I have long lamented that no perſon has ever conſidered this fatty ſubſtance in the light of a manure. It is an animal body, and, beyond all doubt, capable of being reduced, by putrefaction, into a rich vegetable food. The only thing that remains, is to direct the farmer in the manner of its application.

In September laſt I collected about a ton of it, which I mixed into a heap with four loads of freſh horſe dung. This ſpring I propoſe to mix it up with a proportionable quantity of ſuch materials as are uſually collected for forming a compoſt dung-hill, and I flatter myſelf that it will prove a rich and cheap compoſt. I do not take upon me to ſay that this is the beſt method of uſing the whale fleſh. It will give me pleaſure to hear that others have applied it differently, being well aſſured that perfection can only be attained by the concurring aſſiſtance of many. I boaſt of no other merit beyond giving the original hint. There was a time when the richeſt manures, produced in cities and large towns, were either conveyed into the ſea, or thrown into rivers. We have now the ſatisfaction to ſee that method univerſally condemned.

In order to encourage the farmer to ſeek after the refuſe of train oil, I might obſerve that no manure has hitherto been found of a richer quality than the putrid offal of fiſh. In ſome parts of Cornwall they manure their lands with pilchards in a plentiful ſeaſon, and find that no manure equals them in richneſs.

It is allowed on all hands, that putrid vegetables make good manure; but it ſhould be remembered, that animal bodies, when reduced into the ſame ſtate, act more powerfully, and preſerve the land much longer in ſtrength and vigour.

We cannot pay too much attention to every thing that relates to manures; without their aſſiſtance the richeſt ſoils would ſoon be reduced, by frequent cropping, to a barren ſtate. It is pleaſing to obſerve how the diſſolution of one body is neceſſary for the life and increaſe of another. All nature is in motion. In conſequence of the putrid fermentation that is every where carried on, a quantity of vegetable nutriment aſcends into the atmoſphere. Summer ſhowers return much of it again; but part falls into the ſea, and is loſt. To this we may add, the animal and vegetable ſubſtances conſumed on board of ſhips, all of which are buried in the ocean. The induſtry of man reſtores them to the earth; and we may preſume that the fiſh taken from the ſea, leave a balance in favour of mankind. Thus providence, with the moſt conſummate wiſdom, keeps up the neceſſary rotation of things.

EXPERIMENT IV.

On the Oil-Compoſt *.

In the month of May I planted twelve alleys that lay between my aſparagus beds with cauli-flower plants. Each alley took up about thirty plants. One of the alleys I ſet apart for an experiment with the oil-compoſt, which which was prepared according to the directions given in the firſt volume of the Georgical Eſſays.

About a handful of the compoſt was put to the root of each cauli-flower plant. In all other reſpects the alley was managed like the reſt:

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* By Mr. Roebuck, Gardener in York.

The plants in general flowered very well; but thoſe to which I applied the compoſt, ſprung up haſtily with ſmall ſtalks, and produced very poor flowers.

I imputed this unfavourable appearance to the freſhneſs of the compoſt, which was only a few weeks old. In all future trials I ſhall expoſe it to the action of the air, in order to abate the heat, and neutralize the acrimony of the ſalt.

In the September following this unſucceſsful experiment, I planted the ſame alleys with early cabbages. The neceſſity of meliorating the compoſt, was in this trial fully confirmed. For the cabbages that grew upon the alley, which in May had received the compoſt, were larger, and in all reſpects finer, than the others.

The idea that I entertain of the compoſt is, that, when meliorated in the earth, it is capable of giving a richneſs and freſhneſs to it. Upon this principle I would recommend it to gardeners as a ſubject worthy of further trials.

EXPERIMENT V.

On Siberian Spring-Wheat *.

On the 14th of Apirl, 1770, I ſowed three buſhels and a half of the Siberian ſpring-wheat on an acre, and reaped it with the firſt wheat in the neighbourhood. I had thirty ſtooks, which yielded above three pecks per ſtook. The wheat weighed four ſtone ſix pounds per buſhel.

EXPERIMENT VI.

On the Howard, or large Bedfordſhire Potatoe †.

By all the experiments that have been made, the Howard potatoe is found to produce the largeſt crop. On that account they are chiefly uſed in feeding of cattle. In two beds, four feet wide, and two hundred feet long, I planted in a common field a ſufficient number of ſets of this kind of potatoe, and managed them by the

* By M. Dodſworth, Eſq; of Craike Hall.

† By T. B. Bayley, Eſq; of Hope.

the horſe-hoe. The produce was ſixty-four buſhels, each buſhel, up-heaped, weighing about 70 lb. My cattle eat them boiled, with as much eagerneſs as the beſt ſorts, and came on as well with them. I have built a boiling houſe, &c. on Mr. Young's plan, and during this whole winter have boiled potatoes for my cattle. For the fattening ones, I mix ground oats with them; and for the milk cows, malt duſt; and dare venture to affirm that they are much more profitable than either turnips or cabbages. Once, when my potatoes grew low, I deſiſted giving them to the milking cows. Immediately, though fed with the beſt hay, they fell off amazingly in their milk. I therefore began again, and in a week's time they gave better than one-third more butter. I own this accidental diſcovery gave me much ſatisfaction, as it confirmed my opinion, that potatoes boiled are an excellent winter food for cattle. Their culture is not ſo difficult, at leaſt not ſo precarious, as either turnips or cabbages. Their value is ſuperior, and there is no riſk of their giving a diſagreeable taſte either to butter or milk. Add to this the vaſt increaſe of the Howard potatoe, and its equality with the beſt ſorts when uſed for cattle.

EXPERIMENT VII.

On the Increaſe of Potatoes *.

My gardener cut a large potatoe into nine pieces, which he planted with dung, in a drill, in the garden. By earthing up and laying the ſhoots, he produced 575 ſizeable potatoes, which weighed 8 ſt. 8 lb. Another of my ſervants produced, in the field, 7ſt. of good potatoes from the ſame number of ſets. Tho' this experiment cannot always be executed in its full force in an extenſive ſcale, it ought notwithſtanding to be imitated as nearly as circumſtances will allow. It ſhows, in the moſt diſtinguiſhing manner, the uſe of clean and careful huſbandry.

EXPERIMENT VIII.

On the Increaſe of Potatoes †.

On the 14th of April, I cut a large white potatoe into ſeventeen ſets, which were planted in as many hillocks, at the diſtance of four feet.

In

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* By George Wilſon, Eſq; of Brough.

† By Mr. John Williams, near Coventry.

In the courſe of growing, the plants were earthed up, and upon the 14th of October the crop was taken up: The produce, ten pecks of ſizeable potatoes. At the time that this experiment was made I had ſeveral hillocks, in which I put three and four ſets of the ſame kind of potatoe. But, upon the moſt careful examination, I could not obſerve that theſe hillocks produced a greater crop than the others planted with a ſingle ſet. Hence it is obvious, that the potatoe ſpreads its roots moſt kindly when leaſt crouded.

EXPERIMENT IX.

On the Oil-Compoſt *.

In the year 1769, I made the following trial with the oil-compoſt, which was prepared agreeable to the directions given in theſe eſſays.

				Produce.		
	l.	s.	d.	q.	b.	p.
One acre, ſown with barley and manured with oil-compoſt	0	18	0	5	5	0
One acre adjoining, ſown with barley and manured with rotten dung, twelve loads, worth	3	0	0	4	3	2
			Difference	1	1	2

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* By James Stovin, Eſq; of Doncaſter.

The compoſt barley was bolder and better corn than the other.

In the year 1770, the dunged acre produced of rye, three quarters. The compoſt acre, of ditto, two quarters ſix buſhels.

In the year 1771, the ſame lands were ſown with oats, and the produce was greatly in favour of the dunged acre. This laſt experiment, being contrary to the idea of good huſbandry, was made with a view to determine the *abſolute* ſtrength of the compoſt. All top-dreſſings are exhauſted in the year. The oil-compoſt ſeems to retain its vigour longer. It will here be proper to obſerve, that theſe experimental lands were in a common field, which had been many years under the plow.

EXPERIMENT X.

On the Oil-Compoſt *.

In the ſpring 1770, I prepared a piece of ground for onions. It was laid out into ſix beds of equal ſize, and all ſown at the ſame time.

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* By Richard Townley, Eſq; of Belfield.

Over two of them, the oil-compoſt was ſcattered in a very moderate quantity. Over other two, pigeon-dung. And over the remaining two, ſome of my weed-compoſt, which I eſteem one of the beſt manures, for moſt vegetables, that can be made *.

The onions came up very well in all the beds; but, in about ſix weeks, thoſe that were fed with the oil-compoſt plainly diſtinguiſhed the advantage they had over the reſt, by their luxuriancy and colour; and, at the end of the ſummer, perfected the fineſt crop that I had ever ſeen, being greatly ſuperior to the others both in quantity and ſize.

The ſame ſpring I made an experiment upon four rows of cabbages, ſet at the diſtance of four feet every way. Two were manured with the oil-compoſt, and two with my own. All the plants were unluckily damaged, juſt before they began to form, by ſome turkies getting into the field, and plucking off the greateſt part of the leaves. However, they ſo far recovered as to weigh, in the September following, from 22 to 28 lb. a-piece. The rows proved ſo equal in

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* This compoſt is formed of vegetable ſubſtances reduced into putrefaction.

in goodneſs, that I could not determine which had the advantage.

The ſame year, one part of a field of wheat expoſed to the north-eaſt winds, which that ſpring continued to blow for a month or five weeks, appeared very poor and languid at the time of tillering. Over it I ordered ſome of the oil-compoſt to be ſown with the hand, which not only recovered, but alſo puſhed forwards the wheat plants in that part of the field, ſo as to make them little inferior, if any, to the reſt.

The ſame ſpring I made a comparative experiment upon four contiguous lands of oats, between the oil-compoſt and my own weed-compoſt. The latter had manifeſtly the advantage, though the other produced a very fine and large crop. I alſo tried the oil-compoſt upon carrots, and it anſwered exceedingly well. I did the ſame this year, (1771) both upon them and my onions; and have the fineſt crops of thoſe vegetables I ever ſaw any where upon the ſame compaſs of ground.

EXPERIMENT XI.

A general Idea of the Oil-Compoſt.

This compoſt was originally formed upon the ſuppoſition that oily particles conſtitute the chief nouriſhment of vegetables. The uſe of rape-duſt, and other oily and ſaponaceous manures, place this doctrine in a favourable light. It now remains that we determine the merit of the compoſt by accurate experiments.

The oil-compoſt may be uſed two ways: It may either be ſown upon the ſurface with the hand, or worked into the ſoil by the plow or ſpade. For corn and horizontal feeders, the firſt method is moſt proper. The latter is beſt for cabbages, hops, beans, carrots, and all tap-rooted plants. When diſtributed upon the ſurface, it is ſoon meliorated by the action of the air, rains, and dews. When worked into the ſoil, it is deprived of thoſe neceſſary influences. Here lies a material diſtinction which leads to its right uſe and application.

Previous to the planting of any deep-rooting vegetable, the compoſt ſhould be worked into the ſoil by the plow or ſpade. Its particles, when undivided, are too hot for the tender ſhoots.

Some injudicious inquirers have placed a handful of the compoſt cloſe to the roots of a cabbage plant, flattering themſelves that they were then conducting an *experimentum crucis.* Death, or a feeble vegetation enſued. Hence aroſe an argument againſt the *nutritive* power of the compoſt. Lime, the aſhes of burnt vegetables, ſtale urine, gooſe and pig-dung, when improperly applied, are alſo poiſons. It requires ſome judgment to plan, as well as to reaſon upon an experiment.

Experiments correctly made, conſtitute the baſis on which agriculture ſhould be raiſed; but thoſe experiments ſhould rather be the effect of reaſon than of chance. To plan an experiment well, to trace it minutely through its progreſs, and to draw a juſt concluſion, requires a perfect knowledge of the hiſtory of nature and of art. From a defect in theſe particulars, we often become haſty in our praiſe, as well as indiſcreet in our cenſure.

From a variety of experiments, I find that the compoſt ſhould be prepared ſome months before it is uſed: It ſhould alſo be frequently turned and expoſed to the influence of the atmoſphere. This laſt operation is abſolutely neceſſary when the compoſt is intended to be worked into the ſoil with the ſpade. By that means the acrimony of the ſalt will be abated, and the plant, inſtead of being burnt up, will be encouraged to ſpread its roots in queſt of nouriſhment.

It will here be neceſſary to obſerve, that the oil-compoſt was originally intended as a ſubſtitute for rape-duſt, and other expenſive top-dreſſings. In all reſpects it muſt be conſidered as inferior to rotten dung.

EXPERIMENT XII.

A profitable Method of ſowing Wheat on Land too ſtrong for Turnips *.

In the year 1768, I had a field of about ſix acres, which, in the common courſe of huſbandry, ſhould have been ſummer-fallowed, in order to prepare it for ſowing wheat at the latter end of the year. The ſoil being a looſe crumbling clay, I ſowed it with rape, about a fortnight before midſummer, inſtead of fallowing.

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* By Mr. E. Cleaver, of Whitwell, near York.

On the 25th of September, it was ſtocked with ſheep, and eat cloſe to the ground; and about a month after that, it was ſown with wheat upon one plowing. The winter being open, great part of the rape, which was plowed in, revived in the ſpring. This, I feared, would endanger the crop. In that ſituation things remained till about the 20th of April, at which time I thought the rape was in full ſap. I therefore judged this the moſt favourable ſeaſon for deſtroying it. For that purpoſe I turned in as many ewes and lambs as eat both rape and wheat down in a week; and this had the deſired effect, by utterly deſtroying the rape. The field was then left to take its chance. As no weeds appeared, there was no expence upon that article. The produce was thirty-ſix buſhels per acre, Malton meaſure, which is five per cent. above Wincheſter.

I muſt here obſerve, that the year 1769 was remarkable for the largeneſs of its produce on lands in general, and, though I am very inclinable to prefer this method of cultivating wheat, yet, upon an average, I ſhould think that twenty-eight buſhels per acre is as much as we can reaſonably expect, though the land be in good condition.

I ſay I am inclined to prefer this method, becauſe turnips would be of little value to eat off on that kind of land, and at that early ſeaſon of the year, when they are not ſufficiently ſwelled. Were we, in order to remove that difficulty, to ſow them earlier than the uſual ſeaſon, they would probably be either thick-necked or run to ſeed.

It will hardly be neceſſary to obſerve, that the corn produced upon this field was remarkable for the goodneſs of its quality.

The produce:	l.	s.	d.
36 buſhels of wheat at 5 s.	9	0	0
Rape eatage at Michaelmas -	1	10	0
Ditto in April	0	5	0
Per acre	10	15	0

EXPERIMENT XIII.

On Siberian Spring-Wheat *.

On the 2d of April, 1771, I drilled two pecks of Siberian ſpring-wheat on one-third of an acre, in rows one foot aſunder. Previous to ſowing, the wheat was limed in the uſual manner. The land a rich loam, which had borne a crop of turnips fed off with ſheep. The turnips were fine ones, and the land, which lets at ſixteen ſhillings per acre, was in ſuch good order, that I judged one plowing a ſufficient preparation for the wheat crop. The ſeaſon was at firſt unkindly, and the corn came up very thin, with many weeds amongſt it. It was hand-hoed, and ſoon after flouriſhed and tillered amazingly. Though it appeared fine about the time of maturity, there were, notwithſtanding, many weeds amongſt it, and it did not ſeem quite a full crop. In the beginning of October the corn was cut, and on the 19th of the ſame month was thraſhed. The produce, 12 buſhels, 2 pecks, viz. 25 for 1. This appears a conſiderable produce on the ſeed ſown. The grain was well ripened, and in appearance (for I have not yet ſent it to the mill) not inferior to any of the common wheats ſown at the uſual time. This kind of wheat ſeems a real acquiſition to huſbandry; and yet ſome common white wheat, ſown at the ſame time, had the appearance, whilſt growing, of producing ſomewhat a larger crop, only it did not ripen ſo kindly, and was alſo later in ripening.

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* By Sir Digby Legard, Bart. of Ganton.

ing. But if this Siberian wheat was ſuperior to the common ſpring-wheat, it was certainly greatly inferior to ſome wheat of Switzerland ſent me by the Society of Arts, and ſown on land contiguous to the above, and at the ſame time. This laſt was as fine a crop as one could look on, ripened a fortnight ſooner than any of my ſpring-wheats, and was as early as any of the autumnal ſorts.

EXPERIMENT XIV.

On the Method of raiſing Seedling Potatoes.

Take a bunch of the apples of a white potatoe. Hang it up in a warm room during the winter, and in February ſeparate the ſeeds from the pulp, by waſhing the apples in water, and preſſing them with the fingers. Then dry the ſeeds upon paper. In the month of April, ſow theſe ſeeds, in drills, in a bed of earth well dug, and manured with rotten dung. When the plants are about an inch high, draw a little earth up to them with a hoe, in order to lengthen their main roots. When they are about three inches high, dig them up with a ſpade, and ſeparate them carefully from each other, in order for planting out in the following manner.

Prepare a piece of freſh ground by trenching it well. Dig up the ſeedling plants as before directed, and plant them out in the ground, thus prepared, in ſuch a manner, that there ſhall be ſixteen inches between each plant. As they advance in growth, let them receive one or two earthings up, in order to lengthen the main root, and encourage the ſhoots under ground.

By this management the potatoes will, in the courſe of one ſeaſon, arrive at the ſize of hen's eggs, and the haulm will be as vigorous as if ſets had been planted. But what proves the luxuriancy, in the moſt convincing manner, is, that flowers and apples are produced.

In Lancaſhire, where the gardeners raiſe potatoes from ſeed, they are always two, and ſometimes three years in bringing them to full ſize. By the above method of tranſplanting, with wide diſtances, many of the potatoes will attain their full ſize in one ſeaſon.

It is obſervable, that theſe ſeedlings produce potatoes of all the different kinds; and ſometimes new ſorts are procured. We do not find any difference whether the apple comes from a round or a kidney kind. It is not ſo when we uſe the ſet, which invariably produces the ſame kind.

Apples taken from a red potatoe that has flowered in the neighbourhood of white ones, will produce both red and white ſorts, as I found from an experiment made in the year 1773—and I preſume, for the ſame reaſon, that apples taken from a white potatoe that has flowered in the neighbourhood of red ones, will produce both red and white kinds. This proves to a demonſtration, that the male farina is received into the female organ, without which there could not poſſibly be an impregnation of the ſeeds lodged in the ovarium. The idea of animal generation, as given us by Lewenhoek, is ſimilar to this, and is in a great meaſure confirmed by it. In both caſes, however, there remains a difficulty in explaining how thoſe mongrel productions are formed, that partake of the nature of the male and female parents. But this diſquiſition is foreign to the preſent purpoſe, and more properly belongs to the Eſſay on the Sexes of Plants.

Potatoes, when propagated from ſets, after a number of years, are found to decreaſe in bearing;

ing; for which reaſon they ſhould be brought back every fourteen years to their original.

From a want of attention to this circumſtance, I have known potatoes ſo run out, that they hardly returned treble ſeed. The farmer complains that his land is tired of them, but the true cauſe is the age of the ſets.

The increaſe of potatoes raiſed from ſeed is aſtoniſhing. They continue in vigour for about fourteen years; after which, the produce gradually declines.

EXPERIMENT XV.

On the Alternate Huſbandry *.

The alternate huſbandry ſeeming well calculated for lands in this part of the world, I was induced to make trial of it in a field of forty acres Iriſh †; the ſoil a good kind of loam, but ſo full of large ſtones as continually to interrupt the plow. Add to this its being ſadly mangled with old rotten ditches, the foundations of which were moſtly compoſed of theſe large ſtones. To bring this field into proper culture, the alternate huſbandry was admirably calculated, as it gave me an opportunity of rolling off the ſtones and rubbiſh upon the lea; where they remained till I had leiſure to remove them. Theſe ſtones I got drawn off, and built into a wall five feet high, at the rate of three ſhillings the rod (21 feet); and which I may have capped and pointed with lime-mortar for half a crown more. By this method I get a fence that will laſt for ever. Agreeable to this plan I propoſe to divide my whole farm into incloſures of ten acres Iriſh. My grounds being much expoſed to the ſea, I prefer that ſize on account of the ſhelter.

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* By Lewis Irvin, Eſq; of Tanrigoe, in the Kingdom of Ireland.

† Ten acres Iriſh are equal to ſixteen Engliſh.

It was in the ſpring of the year 1770 that I began my experiment upon the alternate huſbandry; and, from what I have obſerved in the firſt year, I am determined to continue that ſyſtem of farming. It diminiſhes the expence of manure, and ſecures a clean fallow; two objects of the utmoſt importance.

I have above obſerved that my experimental field was forty acres Iriſh. The whole was diſpoſed in lands about four yards broad. Somewhat leſs than one half of the field was ſown with 220 ſtone of oats, which is about half the ſeed uſually put into the ground here. The corn ripened kindly, and I reaped 3200 ſtone; a greater crop than my neighbours had from double ſeed. I could not help being greatly ſatiſfied with my ſucceſs, as I was much ridiculed by the name of the Striped-Luteſtring Farmer. The oat lands are now (Jan. 1771) plowed and ſplit, and will be fallowed for wheat in September. The lea lands I ſhall ſow in the ſpring with oats, and make no doubt of obtaining a crop ſuperior to the laſt year.

The period of time employed in this experiment, cannot juſtify me in making abſolute concluſions. It is, however, ſufficient to encourage me to proſecute the plan as laid down in the ſeventh eſſay of this volume.

EXPERIMENT XVI.

The Dimenſions of an Earthen Fence, as made in Northumberland.

The fence muſt be five feet in breadth at the bottom. One foot to be allowed for to plant the

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* By Thomas Riddell, Eſq; of Felton Park, Northumberland.

the Quicks on the ſide next the ditch, and one foot on the other ſide for the breaſt of the dike; ſo that the whole breadth will contain ſeven feet. The fence muſt be made four feet two inches high. The ditch four feet wide at the top, and one yard in the ſlope, and muſt be one foot three inches broad at the bottom. The top of the fence muſt be one foot three inches in breadth. The fence, at the top, muſt be covered with a ſod, the green part uppermoſt. Four Quicks in every foot. Theſe muſt be put in horizontally; ſo that, when the ſtem ſhoots upwards, it forms a right angle with the old ſtock. And this method is found practically better than when the ſet is put down in a perpendicular direction. By this mode of fencing, no poſts or rails are required.——The price in Northumberland is ſixpence for each rood of ſeven yards.

EXPERIMENT XVII.

A Method of preparing a rich Compoſt.

Take a ſufficient quantity of ſaw-duſt. Incorporate with it the blood and offal of a ſlaughter-houſe, putting a layer of one, and a layer of the other, till the whole becomes a moiſt and fœtid compoſition. Two loads of this compoſt, mixed with three loads of earth, will be ſufficient for an acre of wheat, or ſpring-corn. Being a kind of top-dreſſing, it ſhould be put on at the time of ſowing, and harrowed in with the grain.

It will be neceſſary to remark, that this ſpecies of manure ſeems beſt adapted for lands of an open texture. Tough clays require lime and plenty of dung to break the coheſion of their parts. Farmers ſhould attend to this diſtinction.

This preſent year I have a field of wheat manured in this manner, and have the pleaſure to ſay that it is extremely clean, and has all the appearance of turning out an excellent crop. As this kind of compoſt lies in a ſmall compaſs, it ſeems well adapted for the uſe of ſuch farmers as are obliged to bring their manures from a diſtance. It is beſides extremely rich, and will probaby continue in the land much longer than fold-yard or ſtable-dung. I apprehend that it is capable of reſtoring worn-out land to its original freſhneſs; and I am induced to be of that opinion from the appearance of the above wheat crop, which is now growing upon land much impoveriſhed by bad management.

All animal ſubſtances being of the ſame nature, it is probable that the refuſe whale-fat, after the oil is boiled out, will make a compoſt of equal goodneſs with the above. I have at preſent a dunghill made of that offal and horſe-dung hot from the ſtable. I prefer the freſh dung on account of its reducing the blubber more ſpeedily into a putrid ſtate. The preparers of train-oil conſtantly throw this offal into the ſea, but I apprehend that ſaving it for the purpoſes of vegetation will be of national advantage. Being an animal ſubſtance, there is no doubt of its containing all the principles of other animal bodies; conſequently it muſt be an object worthy of the attention of ſuch gentlemen as live in a neighbourhood where train-oil is prepared. We cannot recommend in too forcible a manner, a proper attention to every ſubſtance that is capable of being brought into a ſtate of putrefaction. Notwithſtanding what the ingenious Mr. Tull and others have wrote, it is certain that manures, properly managed, are the life and ſoul of huſbandry. Few things, however, in the extenſive field of rural œconomy, are ſo imperfectly underſtood. Until the doctrine of manures is clearly and diſtinctly laid down, agriculture will remain a vague and uncertain ſtudy.

EXPERIMENT XVIII.

A comparative View of the three different Methods of ſowing Barley *.

It is undecided amongſt farmers which is the beſt method of ſowing grain. To determine the debate, as far as one experiment can be ſaid to determine any thing, I made the following trial,

In a field of twenty acres, which the year before had borne a crop of turnips, I ſelected three contiguous lands, each of which meaſured five roods. The ſoil, a loamy clay of five inches upon a hard bed of chalky lime-ſtone. I ſowed N°. 1 with the four-ſocked drill-plow, in rows eight inches aſunder. N°. 2, under furrow. N°. 3, above furrow. The drilled land was finiſhed in two hours, and took three buſhels and a half of ſeed. The other lands were finiſhed in the uſual time, and had each the ſame quantity of ſeed as the drilled part. The ſaving in ſeed is not an object of ſo much importance

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* By the Rev. Sir William Anderſon, Bart. of Kilwick.

importance in the drill huſbandry as is commonly imagined. On the contrary, I am of opinion that the failure of drilled crops often proceeds from too great an attention to this œconomical part of the ſyſtem.

For about a fortnight after ſowing, the ſeaſon was rather dry. N°. 1 appeared firſt. N°. 2, next. N°. 3, laſt. During the time of growing, the lands had the appearance of being equally good, and, as the ſeaſon was a favourable one for barley, the ears ripened kindly.

On the 4th of October the corn upon the three experimental lands was cut.

The produce:

N°. 1.	60 ſtooks.
2.	67 ſtooks.
3.	65 ſtooks.

Not having the opportunity of thraſhing out the whole crops at this ſeaſon of the year, I ordered one ſtook of each land to be houſed, and carefully thraſhed.

Meaſure:

N°. 1.	3 pecks.
2.	3½ pecks.
3.	3 pecks.

To be ſatisfied of the relative goodneſs of each, I weighed the products.

Weight:
N°. 1. ——— 2 ſt. 12 lb.
2. ——— 3 ſt. 3½ lb.
3. ——— 2 ſt. 9½ lb.

From this experiment we are led to make the following reflections.

1. That ſowing barley under furrow gives the greateſt produce.

2. That ſowing above furrow is next.

3. That drill-ſowing in equi-diſtant rows of eight inches is inferior, in quantity, to both.

4. That the drilled barley is conſiderably the heavieſt.

5. That the under-furrow is next.

6. That the above-furrow is lighteſt.

I ought here to obſerve, that N°. 2 had two plowings, but that N°. 1 and N°. 3 were ſown upon a ſingle plowing. It will alſo be proper to remark that, for want of experience in the perſon who conducted the drill-plow, the bouts were not ſo regular as they ought to have been, which occaſioned, in many places, a conſiderable loſs of land. From theſe circumſtances I am induced to think the experiment not ſo perfectly deciſive as I could wiſh. In a ſhort time I hope to be able to meaſure and weigh the whole produce, by which means the above comparative trial will be rendered more concluſive.

EXPERIMENT XIX.

On the Oil-Compoſt *.

On the 1ſt of October, 1771, I ſowed two acres of a light channelly ſoil with wheat, and harrowed in the compoſt with the grain. Being at a conſiderable diſtance from a large town, we find it very difficult and expenſive to procure rotten dung in ſufficient quantity for our tillage lands, for which reaſon we have recourſe to hand-dreſſings both for our winter and ſpring corn. Rape-duſt and ſoot are principally uſed, but the preſent price of both theſe articles is a heavy tax upon the farmer. To obviate that inconvenience, I reſolved to make trial of the oil-compoſt, and from what I have obſerved in this one experiment, I am encouraged to make a more extenſive uſe of it next year. Being well acquainted with the nature and efficacy of ſoot, I am ſatisfied that the above two acres produced as good a crop of wheat as if they had been dreſſed with that excellent manure.

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* By Mr. J. Broadbent, of Barwick in Elmet, near Leeds.

EXPERIMENT XX.

On the Juice of Carrots, &c.

For many years carrots were appropriated to culinary uſes only. They are now found to be an excellent food for horſes and hogs *. I have often thought that their expreſſed juice might be converted by a cheap proceſs into wine, ſpirit, and vinegar. Some experiments that I made in the year 1772 †, though I failed in ſucceſs, confirm me in that opinion.

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* *Vid.* the ingenious Mr. Young's Eſſay on the Management of Hogs.

† The vinous fermentation went on agreeably for about ſix hours, after which it ſuddenly ceaſed. This experiment was ſeveral times repeated, and with the ſame appearances. Probably a portion of brown ſugar, or molaſſes, may be of uſe in keeping up the fermentation; though, from the ſweet taſte of the juice, one would not ſuſpect an addition of that kind neceſſary. The pulp of the carrot, when mixed with bean meal, makes an excellent food for hogs, and is preferable to grains for milk cows.

I beg leave to recommend to the philoſophical farmer an examination of the carrot juice. It is a ſubject worthy of his attention. One acre of good carrots (eighteen tons) will produce forty hogſheads of a ſaccharine juice. Dr. Marggraf was not able to obtain chryſtallized ſugar from carrots, though he got it from ſkirrets and beets. An examination of theſe juices, with a view to obtain wine, ſpirit, and vinegar, may be worthy of notice. The proceſs for ſugar is too expenſive for practical uſe.

As an inducement to others, I ſhall here ſubjoin Dr. Marggraf's experiments.

" The plants" ſays this ingenious inquirer, " which I chemically examined in order to extract ſugar from their roots, and which yielded a conſiderable quantity, are very common in moſt countries, and require neither a fine ſoil nor aſſiduous culture; ſuch, for inſtance, are,

1. White Beets.
2. Skirrets.
3. Red Beets.

" The roots of theſe three plants yielded a large quantity of pure ſugar. You may know the roots of the plants which contain ſugar by theſe characteriſtics: when you have cut the roots in pieces, and wiped them very clean, they have a very agreeable taſte; and if you examine the pieces by a microſcope, you will perceive whitiſh chryſtalline particles, which are a true ſugar.

" As ſugar is a ſalt which diſſolves even in brandy, I imagined that the ſugar might be ſeparated from the parts of plants by means of the beſt and ſtrongeſt brandy I could get. Previouſly to determine the quantity of ſugar diſſolvable this way, I put into a glaſs an ounce of the fineſt and beſt ſugar well pulverized, together with four ounces of the ſtrongeſt brandy; the whole being well digeſted, I boiled them together, and the ſugar was ſoon perfectly diſſolved. Whilſt this ſolution was yet warm, I ſtrained it through a linen cloth into another glaſs; I corked it cloſe, and, after it had ſtood eight days, I had the pleaſure of ſeeing the ſugar form itſelf anew into very fine cryſtals: to ſucceed in this experiment, the ſugar and glaſs muſt be quite dry, and the brandy well rectified.

Having prepared the way by this experiment, I took the roots of white beets, and, having cut them into ſmall ſlices, I laid them by the fire to dry, taking care not to burn them; I then reduced them to a coarſe powder, and laid it to dry a ſecond time, becauſe it is very apt to contract moiſture: whilſt this coarſe powder was yet warm, I put eight ounces of it into a glaſs veſſel, and poured upon it ſixteen ounces of brandy, ſo ſtrong that it fired gunpowder. The veſſel was above half full, and having corked it cloſe, I ſet it in a ſand-heat till the brandy began to boil; ſtirring it from time to time that the powder might not ſettle to the bottom.

"As ſoon as the brandy began to boil, I took the veſſel off the fire, and poured the mixture as quickly as poſſible into a linen bag, and preſſed it well to ſqueeze out all the liquor; I then paſſed this liquor through a linen cloth whilſt it was yet warm, and put it into a glaſs veſſel well corked, and ſet it in a warm place. The liquor was at firſt turbid, but after ſome weeks a cryſtalline ſediment appeared, which had all the characters of an impure ſugar, and was full of very hard cryſtals. To purify them yet more, I diſſolved them a ſecond time in brandy, and proceeded in the ſame manner as I had done with the real ſugar.

“ By this method, which was the firſt that I fell upon, I obtained from the three roots above mentioned the following quantities of ſugar:

1. From half a pound of white beets, half an ounce of pure ſugar.
2. From half a pound of ſkirrets, an ounce and an half of pure ſugar.
3. From half a pound of red beets, one ounce of pure ſugar.

“ It is evident, from theſe experiments, that lime-water is not at all neceſſary to dry and thicken the ſugar, as ſome pretend, ſince the ſugar cryſtallizes without it.

“ Being thus aſſured that there was real ſugar in plants, I endeavoured to find out a leſs expenſive manner of extracting it; and the beſt way ſeemed to me, firſt to preſs out the juice of the plants, then to purify this juice, and to prepare it for cryſtallizing by evaporation; and laſtly to purify the cryſtals that proceeded from it.

"I took a certain quantity of ſkirrets; I cut the roots, whilſt freſh, into ſmall pieces, and pounded them as ſmall as poſſible in an iron mortar; I then put them into a linen bag, and preſſed out the juice in a preſs prepared for the purpoſe: after this I poured water upon the roots remaining in the bag, and preſſed them a ſecond time. I then put the liquor all together into a very clean veſſel, and let it ſtand to ſettle in a cool place for forty-eight hours; in which time it became clear, and a mealy ſubſtance ſettled to the bottom; I then poured off the liquor gently, and paſſed it thro' a linen cloth into another veſſel.

"The firſt clarification being thus made, I put ſome whites of eggs to the juice, and boiled it in a braſs pan, ſcumming it continually till no further impurities appeared on the ſurface; I then paſſed it through a linen cloth, and the liquor was as tranſparent as the cleareſt wine. I boiled it again in a leſs pan till it was conſiderably decreaſed, and ſo again and again, in yet leſs veſſels, till there remained only a pretty thick ſyrup, which I put into a very clean glaſs veſſel, and ſet it in a warm place. I let it ſtand above ſix months, and then found the ſugar ſticking to the ſides of the glaſs in the form of little cryſtals.

" To purify theſe cryſtals I put the veſſel into warm water, and when the heat had penetrated the glaſs ſo as to render the mixture fluid, I poured both the liquor and cryſtals into an earthen veſſel, broad at top and narrow at bottom, and the bottom perforated with ſeveral holes; this veſſel I put into another, and covered both up, and ſet them in a temperate place: by theſe means the ſyrup gradually dropt into the lower veſſel, and the cryſtals were left in the upper one. This crude ſugar I then put into blotting paper folded different ways, and preſſed it lightly in a preſs; this dried it, and rendered it more pure, the paper imbibing a good deal of the tenacious, viſcid ſyrup which yet ſtuck to the ſugar.

" The ſugar, thus cleaned of the greateſt part of its impurities, I diſſolved again in water, paſſed it through a clean linen cloth, and boiled it to the conſiſtence of a thick ſyrup, then put a little lime-water to it, and boiled it gently till it became ropy; I then took it off the fire, and ſtirred it about till it cooled and thickened a little; after which I poured it into a well-burnt earthen veſſel in the form of a cone, cloſed at the ſmall end with a wooden ſtopper, which veſſel I put into others that were deeper, and ſet them in a temperate place. In a few days the ſugar became tolerably hard and full of cryſtals: and, when it had ſtood eight days, I took out the ſtopper, and ſet the veſſels in a warm place that the ſyrup might run off: this ſyrup is fit for the ſame uſes as common treacle; and the ſugar, after drying and purifying by means of the blotting paper as before, is equal to the beſt brown ſugar of St. Thomas, commoly called Moſcovad. By a ſimilar proceſs, ſugar may be extracted from red and white beets. The ſugar of ſkirrets is of a better quality than that of red beets, but the ſugar of white beets is beſt of all.

" I endeavoured to extract ſugar from the ſtems and leaves of theſe plants, but could obtain from them only a ſort of tartar: it is very remarkable that the roots of theſe plants ſhould contain ſugar, and that the ſtems and leaves ſhould be entirely deſtitute of it.

" Theſe experiments may be uſeful to farmers and other people of this country in low circumſtances. Inſtead of buying ſugar, which is very dear, they may obtain it from the plants at their own doors: they need not go through all the ſteps of the foregoing proceſs; for them it may ſuffice to expreſs the juice, to ſtrain and purify it a little, and then to boil it down to the conſiſtence of a ſyrup, and ſo uſe it; it will certainly be more pure than the groſs treacle of the ſhops. Beſides, from theſe experiments we learn, that thoſe countries which produce the ſugar-cane, are not the only ones which nature hath furniſhed with ſugar.

"I made trials upon ſeveral other vegetables beſides thoſe I have mentioned; I could obtain no ſugar from carrots; the juice they yielded was extremely ſweet, but reſembled honey rather than ſugar; parſnips yielded a little ſugar; two ſpecies of dogs-graſs yielded a very ſweet juice, but not ſugar; the juice of the Birch-tree yielded a ſort of manna."

From theſe experiments it is abundantly evident, that many common roots of this country contain a large ſhare of ſaccharine juice. They conſequently are capable of being converted into wine, ſpirit, and vinegar. To determine this point, (in 1773) I took 24 buſhels of carrots in the month of October. After being waſhed, topped, and tailed, I put them into a large brewing copper with four gallons of water, and covering them up with cloths, to haſten the maceration, I ordered a fire to be kindled underneath, which in a ſhort time reduced the whole into a tender pulp. They were then put into a common ſcrew-preſs, and the juice taken from them, which, together with the liquor left in the copper, was run thro' a flannel bag. The juice was then returned into the copper, and, as it was my deſign to make it into ale, I put to it a proportionable quantity of hops. The liquor was then boiled about an hour, when it acquired both the taſte and colour of wort. It was next put into a cooler, and afterwards into the working veſſel, where the yeaſt was added to it. It worked kindly, and in all reſpects was treated as ale. I allowed it to remain in the caſk about four months, when I broached it, but found it of a thick and muddy appearance. I attempted to fine it, but in vain. The taſte was by no means diſpleaſing, as it much reſembled malt liquor. My firſt intention being fruſtrated, I threw it into the ſtill, being about forty gallons in meaſure, and by two diſtillations obtained four gallons of a clean proof ſpirit. It had, however, contracted a flavour from the hop, which ſhould be left out when the intention is to reduce the liquor into ſpirit. From a groſs calculation, I am induced to think that a good acre of carrots, manufactured in this manner, will leave a profit of forty pounds after deducting the landlord's rent, cultivation, diſtillation, and other incidental expences. In this calculation, I preſume that the ſpirit is worth ſix ſhillings per gallon, and not exciſed. An acre of barley will by no means produce ſo much ſpirit. A rich ſandy loam is the beſt land for carrots, which, after the crop is removed, will be in high cultivation for corn. The ſucceſs of my trial, will, I flatter myſelf, be the means of inducing others to repeat the experiment, with a view to determine how far the growth of carrots for the uſes of the diſtiller may be conſidered in the light of a national advantage.

EXPERIMENT XXI.

On a Method of raiſing Potatoes in Winter *.

Make a compoſt of earth, ſand, and coal-aſhes. With this mixture fill a tub about ſixteen inches deep. Plant this artificial ſoil with

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* By Mr. Seth Agar, York.

ſome ſets of the early round potatoe, and place the tub in a ſtable oppoſite to a window, taking care to water the earth now and then. In all ſeaſons the ſets will ſprout, and give a tolerable increaſe of potatoes. Laſt November I planted ſome ſets in the above manner; and, in the February following, I took up a conſiderable number of young potatoes, clean ſkinned and well flavoured.

EXPERIMENT XXII.

On the moſt profitable Method of managing light Arable Lands *.

A judicious courſe of crops conſtitutes a moſt eſſential part of an arable farm. The following is practiſed in Norfolk, a country remarkable for the beſt courſes.

Firſt Year——TURNIPS.

1. Plow the ſtubble up about Chriſtmas.

2. The beginning of March, plow again and harrow.

3. The beginning of April, plow and harrow; but before you begin to plow this third

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* By the Rev. Mr. Buxton, Norfolk.

time, ſpread twelve loads of good manure upon each acre.

4. Plow again a fortnight before Old Midſummer; then ſow your turnip-ſeed, two pints to an acre, and harrow it in.—Hoe the turnips twice.

Second Year——BARLEY and CLOVER.

Get the turnips off the beginning of March—plow and harrow. Three weeks after, plow and harrow again. The latter end of April, or beginning of May, plow the third time; but before you begin to plow, ſow half of the ſeed upon the land, namely, a buſhel and a half per acre, then plow and ſow the ſame quantity of ſeed above furrow. Harrow once; then ſow ten pounds of good clover-ſeed, and let the barley and clover be harrowed in together.

Third Year——CLOVER.

Take two crops of clover; or, if you think proper, reſerve the ſecond crop for ſeed.

Fourth Year——WHEAT.

A fortnight, or three weeks, after Old Michaelmas, plow your land. As ſoon as plowed, throw two chaldrons of hot lime upon each acre. Harrow the lime and the ſeed in toge-

ther.

ther. Provided the land be clean, I think two buſhels of wheat or barley ſufficient ſeed for an acre.

Expence of the Turnip Crop.

	l.	s.	d.
Four plowings and harrowings, at 3 s. 6d. each	0	14	0
Twelve loads of manure, and carriage, at 5 s. per load	3	0	0
Seed, two pints, 1 s. Hoeing twice, 7 s.	0	8	0
	4	2	0

Expence of Barley and Clover.

	l.	s.	d.
Three plowings and harrowings, at 3 s. 6d. each	0	10	6
Seed, two buſhels, 5s. Clover 10s.	0	15	0
Reaping 1 s. 6d. Beer 1 s. 6d. Getting in 5 s.	0	8	0
	1	13	6

Expence of the Clover Crop.

	l.	s.	d.
Cutting and beer 2 s. Making 1s.	0	3	0
Carrying 5 s. Second crop 7 s. 6d.	0	12	6
	0	15	6

Expence

Expence of the Wheat Crop.

	l.	s.	d.
Plowing once and harrowing	0	4	0
Lime, 2 chaldrons, 1l. Carriage 10s.	1	10	0
Seed, two buſhels	0	10	0
Reaping 6s. Beer 1s. 6d. Carrying 5s.	0	12	6
	2	16	6

Expence of the four Years.

	l.	s.	d.
Turnip crop — — —	4	2	0
Barley ditto — — —	1	13	6
Clover ditto — — —	0	15	6
Wheat ditto — — —	2	16	6
	9	7	6

	l.	s.	d.
Nine pounds ſeven ſhillings and ſixpence, for four years, makes each crop upon an average	2	6	10½
Add rent 1l. Tithes and rates 7s. 9d.	1	7	9
Rent, rates, and cultivation per acre	3	14	6

Profits of four Crops.

	l.	s.	d.
Turnip crop worth — —	3	0	0
Barley ditto, 36 buſhels at 2s. 6d.	4	10	0
Carried over	7	10	0

	l.	s.	d.
Brought over	7	10	0
Clover ditto, firſt crop, three loads	3	0	0
Second ditto, two loads —	2	0	0
Wheat ditto, 28 buſhels at 5s.	7	0	0
	19	10	0

	l.	s.	d.
Nineteen pounds ten ſhillings, makes each crop upon an average — — —	4	17	6

	l.	s.	d.
Profit per acre — —	4	17	6
Expences — — —	3	14	6
Clear profit per acre	1	3	0

Lands cultivated in this manner will never be over-run with weeds; neither can the ground be diſtreſſed, as tap-rooted plants regularly follow ſuch as ſpread their roots ſuperficially.— The ſyſtem is founded on reaſon, and ſupported by experience.

EXPERIMENT XXIII.

A Method of making excellent Butter from the Milk of Cows fed upon Turnips [*].

Let the bowls, either lead or wood, be kept conſtantly clean, and well ſcalded with boiling water before uſing. When the milk is brought into the dairy, to every eight quarts mix one quart of boiling water; then put up the milk into the bowls to ſtand for cream. By keeping ſtrictly to this method, I have conſtantly, during the winter, ſweet and well-taſted butter from the milk of cows fed upon turnips. My cows are kept in the houſe at nights to hay, and are turned out in the day-time to turnips without waſte.

EXPERIMENT XXIV.

A new and profitable Method of raiſing a Crop of Turnips in Drill [†].

At this time, every one knows the conſequence of turnips to the farmer in ſupporting his lean ſtock, and keeping up his fat in the winter ſeaſon at an eaſy expence.

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[*] By C. Crowe, Eſq; of Kipling.

[†] By Mr. Benſon, of Stainley.

Though the growth of turnips is now become univerſal in the north of England, yet it does not appear that there is any general regularity obſerved in their cultivation. Particular ſoils hath hitherto determined the preference of turnip crops. This not falling to the lot of every one, induces me to publiſh ſuch obſervations as I have from time to time made in a long ſeries of years.

The firſt preparation for a turnip crop is to plow the land before the froſts ſet in. The benefit of this plowing, critically obſerved, not only meliorates the ſoil, but alſo turns out, and expoſes the eggs of that pernicious inſect, the fly, to the ſeverity of the winter. The next plowing ſhould be performed, croſs-ways, about Candlemas, or before the froſts are quite over, that a farther advantage may be taken over the remaining ova of the fly. The ridges muſt then be harrowed length-ways. After this, the diſcretional uſe of the plow, roller, and harrows is all that is neceſſarry to make a good preparation for ſowing.

The laſt week in May, if the weather be moiſt and gloomy, if not, make uſe of mornings and evenings, begin by ſetting the ridges at one bout, and cloſe them by a crooked harrow, which will lay them in the form of an arch. This being done, a furrow muſt be drawn down the middle of every ridge with a double mould-board plow, to receive the dung, which muſt be laid in heaps (about four to the the load) down every tenth furrow. Six loads (twenty-four buſhels to the load) will be ſufficient for an acre. The dung muſt then be carried in ſcuttles from the heaps, and ſcattered, edge-ways, into the open furrows. Upon the manure thus diſpoſed, the ſeed muſt be drilled by a hand-drill; after which the earth muſt be returned by a common harrow, paſſed croſsways over the lands.

About the fifth day, if the ground is moiſt, the young plants will make their appearance. As ſoon as they have got into rough leaf, they muſt be thinned by women and boys, with a ſmall two-inch hoe. With this hoe, and the fingers, the plants ſhould be left about two inches diſtant, which will be ſufficient for the firſt hoeing. The ſecond hoeing ſhould be performed with a ſix-inch hoe, before the leaves interfere, leaving the plants at about eight inches, which will prepare them for the third and laſt hoeing. This muſt alſo be done before the leaves interfere, allowing from forty to ſixty-five upon a perch, according to the vigour of the plants, and the richneſs of the ſoil. In this laſt hoeing, particular care muſt be taken to cut up all the weeds, and to ſtir the ground near the ridges, where the plow cannot come.

The hoe-plowings neceſſary for compleating the crop are three, and may be performed by a narrow plow of about ſeven inches, made in the common way.

The firſt is done by going round each ridge, and turning a furrow from the plants into the interval. When a number of theſe are finiſhed, the field will appear in double ridges; one half of which will be ſtocked with plants, and the other naked. About a fortnight after this operation, the naked ridges muſt be ſplit with the double mould-board plow, and the earth thrown to the plants. After this, it will be proper to ſend in a few women to pluck up ſuch weeds as have eſcaped the former operations, with a view to prevent their perfecting their ſeed; otherwiſe the tillage intended for the benefit of the crop would produce the ſame effect upon the growth of the weeds, and increaſe them in an amazing degree. The labour of this is ſmall, but the conſequence is important.

Expence per Acre.	l.	s.	d.
Firſt plowing — —	0	5	0
Second ditto — —	0	5	0
Harrowing — —	0	1	0
Third plowing — —	0	4	0
Fourth ditto — —	0	4	0
Harrowing — —	0	0	6
Plowing the ridges at one bout	0	1	6
Plowing the furrows for ſeed	0	0	9
Six loads of dung and leading	1	1	0
Two women to ſpread the dung	0	1	0
A boy for drilling ——	0	0	6
Seed —— ——	0	0	6
Harrowing — ——	0	0	6
Several hand-hoeings and weedings	0	3	6
Three ſeveral horſe-hoeings	0	3	0
Rent —— —— —	0	12	0
	3	3	9

It will not be improper to enumerate the advantages of this method of culture. The ſeed being placed upon the moiſt dung, will vegetate early in all circumſtances of the weather;

ther; and the manure being well covered, will be ſecured from evaporation in the hotteſt ſeaſons. The turnips being placed immediately over the manure, have a ready paſſage, by means of their tap-root, into a rich bed of nutriment, which will accelerate their growth, and increaſe their ſize. As the crop grows upon ridges, with a trench on each ſide, it is obvious that the turnips will remain dry in the wetteſt ſeaſons; a circumſtance of the utmoſt utility. To theſe advantages we may add the doubling of the ſoil, which I conſider as an important article in all ſituations where the ſtaple of the land happens to be thin.

EXPERIMENT XXV.

On the Quantity of Aſhes to be obtained by Burnbaking *.

In Auguſt 1772 I pared and burnt one acre three roods of limeſtone land, and carefully collected the aſhes into two heaps for a future experiment. Having ſo good an opportunity, I meaſured the aſhes, and was much ſurprized at the quantity, being eighty cart loads, thirty buſhels to the load.

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* By A. St. Leger, Eſq.

I ſhall not here enter into the merits of burn-baking; but, from the above experiment, it is obvious that a compleat dreſſing may be obtained, in any country, upon very reaſonable terms.

EXPERIMENT XXVI.

On Spring Wheat *.

On the 6th of April, 1772, I ſowed three roods of a turnip fallow with ſpring wheat, the ſoil about ſix inches deep, upon a limeſtone rock, and valued at ten ſhillings per acre. I had the pleaſure of ſeeing the crop cut down about a week ſooner than the wheat ſown in October, upon the ſame kind of land. Upon theſe three roods I had forty-two ſtooks, ten ſheaves to the ſtook. When threſhed, I had twenty-one buſhels of clean corn; and ſhould have had conſiderably more, had not the lands been much infeſted with ſparrows. I ſhall not determine much upon this ſmall experiment, as I propoſe to enlarge my trials very conſiderably next year. It will, however, be proper to obſerve, that my tenants were deſirous of having part of the ſeed, but I choſe to reſerve it all for myſelf, well knowing that the common farmer ſhould have nothing put into his hands but what has ſtood the teſt of accurate and judicious experiment.

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* By A. St. Leger, Eſq.

EXPERIMENT XXVII.

On ſowing Carrot-Seed.

Carrot-ſeed muſt be ſown early; and as it remains a long time in the ground, the weeds frequently ſpoil the crop. The following method has been found effectually to prevent the above inconvenience.

Take any quantity of carrot-ſeed, and mix it with about five times the quantity of earth. Moiſten the whole with water, and every ſecond day turn the whole over. As ſoon as the ſeeds begin to ſwell and ſprout, they may be ſown along with the earth.

In this method, the carrot-ſeeds will vegetate before the weeds; and the farmer will be ſecure of a good crop, which may be eaſily and cheaply hoed.

EXPERIMENT XXVIII.

The Method of making Whale-Compoſt *.

I have a particular pleaſure in deſcribing and making public the beſt method of forming a compoſt from whales fleſh, as recommended to me by Dr. Hunter. Having marked out the length and breadth of your intended dunghill, make the firſt layer of earth about a foot in thickneſs. Moor-earth, or ſuch as is taken from ant-hills, is the beſt for this purpoſe. Over the earth lay one layer of long litter from the fold-yard, or ſtable, about twelve inches in thickneſs, then a layer of whale-fleſh, and over that another layer of dung. Repeat the operations till the heap be raiſed about ſix feet, then give it a thick covering of earth, and coat the heap with ſods. In this manner, each layer of fleſh will be placed between two layers of dung. In about a month turn the whole in the uſual manner, which will occaſion a ſtrong degree of heat and fermentation. When turned, coat with earth as before, with a view to confine the putrid ſteam which would otherwiſe eſcape. In

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* By Mr. Charles Chaloner.

a month or two the heap will be found conſiderably fallen, when it ſhould have a ſecond turning as before. The operation of turning muſt be repeated at proper intervals, till the whole becomes an uniform putrid maſs. The whale-fleſh is of different degrees of firmneſs, ſome of it being almoſt liquid; and, in proportion to its firmneſs, the heap will become ſooner or later fit for uſe. In general the compoſt ſhould not be uſed until twelve months old; but that depends upon circumſtances. Guard the heap from dogs, pigs, badgers, and vermin, as theſe animals are remarkably fond of whale-fleſh.

This animal compoſt may, with great advantage, be applied to all purpoſes where good rotten dung is required. I have uſed it with great ſucceſs for cabbages, and find it an excellent dreſſing for meadow ground. Accordding to the beſt computation, one hogſhead of whale refuſe will make eight loads of dung, which, when we conſider the great facility with which this baſis of our dunghill may be carried, is a momentous concern to ſuch farmers as lie remote from a large town.

When we take a view of the vaſt quantities of whale refuſe that uſed formerly to be thrown into the ſea, to prevent the bad effects of its putrid ſteams, and now ſurvey it as converted into the beſt of dunghills for enriching our fields and paſtures, we are inſenſibly led to return thanks to the editor of theſe eſſays, who has proved to a demonſtration, that huſbandry muſt be regulated and directed by the powers of reaſon and reflection.

EXPERIMENT XXIX.

A comparative View of Top-Dreſſings *.

In the middle of March, 1771, I plowed a rood of land flat; the ſoil a poor, wet, hungry gravel, with many blue pebbles. Thro' the year 1770 it was fallowed, receiving five plowings. On the firſt of April I marked ſeventeen diviſions, each two perches, and manured them with top-dreſſings, and ſowed them with Switzerland wheat. The manures, expences, product, &c. will appear in the following table.

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* By A. Young, Eſq.

Manure per Acre.	Expence per Acre.			Crop per Acre.				Value of Crop.			Gain by Manure.			Weight per Acre.	Value at 3s. per Ct.			Gain by Manure.		
	l.	s.	d.	Q.	B.	P.	G.	l.	s.	d.	l.	s.	d.	Ct.	l.	s.	d.	l.	s.	d.
Hens dung, 40 buſhels,	1	0	6	2	0	3	1	5	1	3	3	12	11	8 ½	1	5	6	0	9	0
Wood-aſhes, 50 ditto,	1	5	7	1	7	0	0	4	10	0	2	16	8	14 ½	2	3	6	1	7	0
Coal-aſhes, 80 ditto,	1	8	4	1	7	0	0	4	10	0	2	16	8	10	1	10	0	0	13	6
Hens dung, 20 ditto,	0	10	3	1	7	0	0	4	10	0	2	16	8	6 ½	0	19	6	0	3	0
Coal-aſhes, 255 ditto,	4	5	0	1	5	3	0	4	2	6	2	12	2	9 ½	1	5	6	0	9	0
Ditto, 160 ditto,	2	16	8	1	5	0	1	3	18	9	2	5	5	9 ¾	1	9	3	0	12	9
Soot, 80 ditto,	3	0	6	1	4	2	0	3	15	0	1	19	8	10	1	10	0	0	13	6
Lime, 80 ditto,	2	0	6	1	3	3	1	3	11	0	1	17	11	8 ½	1	5	6	0	9	0
Wood-aſhes, 40 ditto,	1	0	6	1	3	1	0	3	7	6	1	13	2	10 ½	1	11	6	0	15	0
Soot, 60 ditto,	2	5	5	1	2	0	0	3	0	0	1	4	8	8	1	4	0	0	7	6
Pigeon-dung, 20 ditto,	0	15	3	1	1	1	1	2	16	3	0	19	11	6 ½	0	19	6	0	3	0
Soot, 40 ditto,	1	10	3	1	1	1	1	2	16	3	0	19	11	5 ¾	0	17	3	0	0	9
Gooſe-dung, 20 ditto,	0	10	3	1	0	0	1	2	8	9	0	10	5	5	0	15	0	—	—	—
Salt, 10 ditto,	3	0	0	0	6	3	1	2	1	3	0	1	11	6	0	18	0	0	1	6
Ditto, 5 ditto,	1	10	0	0	6	2	½	1	19	4	—	—	—	5 ¾	0	17	3	0	0	9
No manure,	—	—	—	0	6	2	½	1	19	4	—	—	—	5 ½	0	16	6	—	—	—
Lime, 160 ditto,	4	1	0	—	—	—	—	—	—	—	—	—	—	8 ½	1	5	6	—	—	—

In 1772 the land was clover, and mown once. The ſixth column gives the crop in hay; the ſeventh, the value; and the eighth, the increaſe by the manures. It would be to little purpoſe to make any obſervations upon the above experiment, as the concluſions muſt be obvious to every perſon. The poverty of the ſoil is ſeen in the crop of corn without manure. The extreme unfavourableneſs of laſt year to hay crops, was the reaſon that the clover produced ſo poorly. The diviſion of 160 buſhels of lime, by miſtake, was forgot to be ſown with wheat.

In March 1773, the rood was plowed up, and oats were harrowed in. Theſe were reaped the middle of Auguſt, and threſhed.

		Products.				Per Acre.			
		P.	G.	Q.	P.	Q.	B.	P.	G.
N°. 1.	——	2	0	2	0	5	5	0	0
2.	——	2	1	1	0	6	4	2	0
3.	——	2	1	2	0	6	7	0	0
4.	——	2	0	2	0	5	5	0	0
5.	——	2	0	2	0	5	5	0	0
6.	——	0	1	2	0	1	7	0	0
7.	——	0	2	1	0	2	6	2	0
8.	——	1	0	2	0	3	1	0	0
9.	——	1	1	0	0	3	6	0	0
10.	——	2	0	0	0	5	0	0	0
11.	——	2	1	2	0	6	7	0	0
12.	——	2	1	2	0	6	7	0	0
13.	——	1	0	0	0	2	4	0	0
14.	——	0	1	2	0	1	7	0	0
15.	——	0	1	2	0	1	7	0	0
16.	——	1	1	2	0	4	3	0	0
17.	——	2	1	0	0	6	2	0	0

Manure.	Expence.			Crop.	Value of Corn.			Gain by Manure.			Gain in three Years.		
	l.	s.	d.		l.	s.	d.	l.	s.	d.	l.	s.	d.
Coal-aſhes, 80 buſhels,	1	8	4	55	6	17	6	3	2	6	6	12	8
Hens dung, 20 ditto,	0	10	3	55	6	17	6	3	2	6	6	2	2
Ditto, 40 ditto,	1	0	6	55	6	17	6	3	2	6	7	4	5
Wood-aſhes, 50 ditto,	1	0	6	52 ½	6	11	3	2	16	3	6	19	11
Soot, 80 ditto,	3	0	6	50	6	5	0	2	10	0	5	3	2
Wood-aſhes, 40 ditto,	1	0	6	45	5	12	6	1	17	6	4	5	8
Coal-aſhes, 160 ditto,	2	16	8	45	5	12	6	1	17	6	4	15	8
Ditto, 255 ditto,	4	5	0	45	5	12	6	1	17	6	4	18	8
Gooſe-dung, 20 ditto,	0	10	3	40	5	0	0	1	5	0	1	15	8
Soot, 60 ditto,	2	5	5	35	4	7	6	0	12	6	2	4	8
Nothing,	—	—	—	30	3	15	0	—	—	—	—	—	—
Pigeon-dung, 20 ditto,	0	15	3	25	3	2	6	—	—	—	1	2	11
Salt, 10 ditto,	3	0	0	22 ½	2	16	3	—	—	—	0	3	5
Lime, 80 ditto,	2	0	6	20	2	10	0	—	—	—	2	6	11
Salt, 5 ditto,	1	10	0	15	1	17	6	—	—	—	0	0	9
Lime, 160 ditto,	4	1	0	15	1	17	6	—	—	—	—	—	—
Soot, 40 ditto,	1	10	3	15	1	17	6	—	—	—	1	0	8

Throughout this round of crops, the benefit of the poultry dung and wood-aſhes is very ſtriking. Eighty buſhels of coal-aſhes alſo appear in the ſame light. Upon what principles 160 and 255 buſhels of coal-aſhes are inferior to 80 buſhels, I know not. From a conſideration of their qualities, I ſhould have expected no good from them; and ſeveral other trials have concurred in confirming me in that idea on poor ſoils; but in the preſent one, 80 buſhels being ſo beneficial, will not allow of ſuch a concluſion. Pigeon-dung continuing ſo indifferent, ſurprizes me very much. The gooſe-dung being ſo high in the table, and the 40 buſhels of ſoot ſo low, are contradictions that I cannot account for. The effect of the lime and ſalt is pretty much what I ſhould have expected.

GENERAL REMARKS.

Upon looking over the table, I cannot draw one general concluſion. If the nature of the ſoil be conſidered, which we have every reaſon to believe full of the vitriolic acid from its natural ſterility, and its abounding with the ſtone called, in Hertfordſhire, Mother-ſtone, (a concretion of many ſmall blue pebbles) we ſhould ſuppoſe that nothing could be ſo effectual as the application of alkalies. It is true the wood-aſhes are excellent, but why not the lime? and why are coal-aſhes in any degree uſeful, whoſe quality I take to be much nearer an acid than an alkali? On the contrary, if we ſet out with a doctrine that has many circumſtances to recommend it, viz. that mucilage is the ſoul of manures, we cannot by any means bring the facts of this experiment to ſpeak the ſame language. The poultry dung, it is certain, does wonders, but why not the gooſe-dung? Why do wood-aſhes, in one year, much exceed it, and always nearly equal it? and why do coal-aſhes exceed it?—Theſe are circumſtances I cannot account for, probably from not being ſufficiently acquainted with the component parts of theſe manures, or the neutral ſalts which may be formed in the ſoil by their application. Indeed we ought not to be deſirous of founding general concluſions on particular trials, ſince, in repetitions, ſeveral important variations may ariſe; and the particular trials, on which we rely too much, then turn out mere exceptions, which are loſt in drawing more general averages.

EXPERIMENT XXX.

On the Oil-Compoſt *.

In the ſpring of the year 1772, a piece of ground was prepared in my garden for onions; and after the ſeed was ſown and raked in, I had the uſual quantity of oil-compoſt ſcattered over it. The ground meaſured forty-eight ſquare yards, including four ſmall paths for the convenience of weeding the crop. Great quantities were pulled up, during the growth of the crop, for the uſe of the family; great quantities were given to my labourers and poor neighbours, and even ſome thrown into my hog-yard, in order to thin the crop properly as it proceeded towards maturity. On the 18th of September the crop was judged to be ſufficiently grown, and ripe enough for keeping during the winter The onions were then taken up; and after laying a few days to harden and dry in the ſun, they were brought in and weighed, when the produce was found to be 304 lb. of a very large ſize. This produce is 6⅓ lb. to a ſquare yard, or 30653 lb. to a ſtatute acre, which, at one penny per pound, the loweſt price in our neighbourhood, amounts to 127l. 14s. 5d. I muſt attribute this extraordinary produce to the oil-compoſt alone, as the ground upon which the onions were ſown had been exhauſted by a conſtant ſucceſſion of different crops for forty years paſt, and was beſides but of a midling quality.

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* By Richard Townley, Eſq; of Belfield.

EXPERIMENT XXXI.

A comparative View of Baron Van Haake's Compoſt, the Oil-Compoſt, and Soot mixed with Aſhes *.

In the beginning of April, 1773, an acre of land was ſown with forward oats. I pitched upon one land in the middle of the piece which I eſteemed better than any of the reſt, and upon this I ſcattered Baron Van Haake's compoſt, in the quantity directed in his inſtructions. On one ſide I manured a land with the oil-compoſt, but rather with a leſs quantity than directed; and on the other ſide I manured two lands with dry coal-aſhes, ſifted fine, and an equal quantity of ſoot. The lands upon which this experiment was made, were much worn out with a long ſucceſſion of crops.

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* By Richard Townley. Eſq; of Belfield.

The lands which had the benefit of the aſhes and ſoot produced an exceeding fine crop; the oil-compoſt produced a tolerable good one; but that land which had only the aſſiſtance of the Baron's compoſt, produced a very poor one. It could not have been worſe, had it been left deſtitute of every aſſiſtance. From this, and from ſome other experiments made by a worthy neighbour of mine, who was ſo kind as to furniſh me with the Baron's compoſt, I have great reaſon to diſcredit the pompous accounts given of its extraordinary powers and qualities by its inventor, which appeared to ſavour ſo much of empiriciſm, that I ſhould hardly have made the above trial, had not my ingenious neighbour intreated me to make the experiment. I ſhould be glad to hear that the Baron's compoſt has ſucceeded better with others who have given it a fair trial; for was it poſſeſſed of half the boaſted virtues aſcribed to it, it would prove a moſt valuable acquiſition to the farmer and the public.

The ſame year in which theſe experiments were made, I tried the oil-compoſt upon ſome parts of my wheat crops, which diſcovered great weakneſs and poverty at the time of tillering, and with conſiderable ſucceſs.

EXPERIMENT XXXII.

On Ægyptian Wheat [*].

In September, 1772, I received from a friend twelve grains of Ægyptian wheat, which I have reaſon to believe was the *Triticum ramoſum et centumgranium* of Pliny, of the produce of which he gives ſuch extraordinary accounts. After giving an account in what parts of Africa this remarkable ſpecies of wheat is produced, he ſays, "Et imprimis Ægypto." Six of theſe grains I gave to a neighbouring gentleman, the other ſix I put down in my own garden, at the depth of two inches within the ſoil, and nine inches diſtance from each other. The ground was kept hoed and clean from weeds, which was the only aſſiſtance that was given to the plants. When the ears became heavy, I ordered the ſtems to be tied up to ſtakes to prevent their breaking down with wind or rain. Theſe ſix grains produced one hundred and two ſtems, with large branching ears, and the ears contained, upon an average, one hundred and twenty grains, or better; ſo that the produce of the ſix grains, at the medium of one hundred and twenty grains to each ear, makes 12,240, or 2040 from each grain. Moſt of the grains were plump and large, and the flour within was of a good colour. I cannot help expreſſing my fears, that this ſpecies of wheat, produced in the fertile ſoil and ſerene climate of Ægypt, will be apt to degenerate in this iſland; though we have often found, by experience, that different kinds of grain, as well as plants, natives of countries far more favourable to vegetation than our own, have flouriſhed very well amongſt us; and to appearance have, in a ſeries of years, aſſimilated their natures to our ſoil and atmoſphere. I propoſe to ſow this kind of wheat at different ſeaſons of the year; and if it can be kept up to its preſent ſtandard, with early ſowing, it will prove a great acquiſition to agriculture. According to my trials, it ſtands our froſts as well as our common wheats; and being a ſtrong-bearded grain, it is well defended againſt the ravages of the birds, which, near villages and incloſed countries, is no inconſiderable advantage.

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[*] By Richard Townley, Eſq; of Belfield.

EXPERIMENT XXXIII.

On the Culture of Cabbages *.

In a field from which I gathered laſt year a prodigious crop of turnips, amounting to one hundred tons per acre, (Cheſhire meaſure) I this year have raiſed cabbages. The land was plowed into ridges of three and a half, or four feet, and each ridge prepared with manure as for potatoes, i. e. the dung or litter was only laid under the middle of the ridge. The plants, raiſed from ſeeds ſown in Auguſt 1772, and tranſplanted on beds in October following, were ſet out in this field at the diſtance of about two feet and a half, or three feet, in March and April; were once hand-hoed and twice horſe-hoed thro' the ſummer, but were greatly retarded in their growth by the exceſſive heats and dry weather in June and July. The number of plants ſet out on a Cheſhire acre was near eleven thouſand.—As a great quantity of my autumn plants were killed in the winter, I ſowed more ſeed in February; but this year's experience, added to that of the preceding ones, has convinced me, that it is abſolutely in vain to expect a weighty crop of cabbages from ſpring plants. The ſorts I ſowed were the North American and Scotch; but I find that the Scotch is, on all accounts, preferable, and far more durable.

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* By T. B. Bailey, Eſq; F. R. S.

In the month of November, I took up and weighed a ſquare rod, or ſixty-four yards, containing ſixty-eight cabbages, of which fifteen or twenty were ſmall, being ſpring plants. The weight was 1211 lb.—on an average 17 lb. or eighty-ſix tons ten hundred.—Taking out fifteen ſpring plants, at 2 lb each, out of the above number ſixty-eight, the average will be 22 lb. or 103 tons to the Cheſhire acre, and this, I take, will not much exceed the acreable produce of my autumn-ſown plants.—Suppoſing, therefore, that, on a medium, each cow or ox eats half a ton a week, or 143 lb. each 24 hours, and that this keep is only worth 4s. per week, an acre of cabbages, as above, at this eſtimate, will be worth 41 l. per acre; but at the firſt calculation of 86 tons ten hundred, it will be worth 34 l.

Expences.

	l.	s.	d.
Rent,	3	10	0
Manure,	5	0	0
Two plowings,	1	0	0
Plants,	4	0	0
Setting,	0	8	0
Hand-hoeing	0	4	0
Two Horſe-hoeings,	0	10	0
Harrowing,	0	3	0
	14	15	0
	34	0	0
	19	5	0

In the account of expences I have rated them beyond the truth, and have eſtimated the land at an high value; but it will be objected, that 5l. an acre is not enough for manure; I anſwer, more than enough for land rich like mine; but allowing 12l. an acre, ſtill the profit will be 12l. 5s.

This account will, I hope, prevail on others to make trial of theſe plants. They come to their perfection when the eddiſh is over, and greatly exceed turnips in feeding either fat cattle or milk cows, and are not only to be ſought for, as they are an excellent food, and produce much dung, but as they ſave hay, which, in general, is very dear and ſcarce in this country, and does by no means produce ſo much milk, or fat beaſts ſo well. Will four ſhillings a-week keep a large cow in fine order when hay is 6d. per ſtone? and it is often more.

EXPERIMENT XXXIV.

The Method of uſing Sea-Weed in Scotland *.

Of ſea-weed there are three different kinds. The beſt is that which is cut from the rocks, and of which kelp is made. The ſecond-beſt is called the peaſy ſort. The worſt is that with a long ſtalk. All theſe kinds are uſed in Scotland, but chiefly for the barley-crop, in which caſe, or for fallow, it is plowed in directly. The people of the country have ſo high an opinion of its fertilizing quality, that they ſometimes lay it on after the barley is in the ground, but that is a ſlovenly and injudicious method. In the neighbourhood of Berwick, it is uſed

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* By Sir A. Purves, Bart.

in their compound dunghills, with fold-yard, ſtable-dung, and earth; and in that manner an immenſe quantity of dung is produced by ſuch farmers as are ſituated near the ſea. In that neighbourhood, the farmers are very intelligent; and it is a pity that ſuch excellent management ſhould be ſo little known in many parts of the northern coaſt of England, where the ſea-weed is produced in great abundance. It is remarkable that ſuch farmers as uſe the ſea-weed properly, have their lands in ſuch heart as ſeldom to have occaſion for a fallow to reſtore their freſhneſs. This ſpecies of manure is experimentally found to be excellent for gardens, as it not only enriches the ground, but alſo deſtroys all kinds of vermin.

EXPERIMENT XXXV.

A comparative View of Manures *.

In the year 1771, I marked out a rood of land into diviſions, and ſowed them with oats. The variety of manures made uſe of in this experiment are marked as follows:

Pro-

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* By A. Young, Eſq.

N°.	Proportion per Acre.	Produce per Acre.	
		B.	P.
1.	40 cubical yards of farm-yard compoſt, earth, and dung,	40	2½
2.	20 ditto,	51	1
3.	10 ditto,	45	0
4.	10 ditto,	46	1
5.	10 loads of bones, each 40 buſhels,	63	1
6.	20 ditto,	57	0
7.	200 buſhels of lime,	38	1¾
8.	40 yards of chalk,	31	1
9.	No manure,	30	2½
10.	80 yards of chalk,	25	2½
11.	120 ditto,	27	2
12.	40 ditto, earth mixed with train-oil, *ſix months ago*, and often turned,	33	0½
13.	40 ditto, earth mixed with urine, *four months ago*, and often turned,	37	2
14.	40 ditto, earth alone,	33	0½
15.	40 ditto, earth from the farm-yard,	35	0
16.	120 ditto, red gravelly loam,	29	1½
17.	160 ditto,	31	1

N. B. The ſeaſon was remarkably dry, which circumſtance certainly had a conſiderable effect upon the different crops.

EXPERIMENT XXXVI.

The Method of preparing Land for ſowing Lucern broad-caſt *.

It having been found by repeated experiments, that broad-caſt lucern will not ſucceed upon lands that are not perfectly clean, I determined upon the following method of preparation, which has ſucceeded beyond my moſt ſanguine expectations.

In the month of Auguſt, 1771, I mowed the graſs from one acre three roods of land intended for lucern, and immediately after the hay was removed I pared and burnt the ſurface. The aſhes were put into two heaps, and covered with ſods, to prevent the influence of the air upon the ſalts produced by this operation. The ground was then plowed as deep as its ſtaple would admit of. On the 11th of November I harrowed it with heavy harrows, and on the 25th I plowed it acroſs. On the 4th of January, 1772, it was harrowed again. One heap of the aſhes was ſpread on the 23d of March, and on the 2d of April the land was plowed and ſown with lentils. Had the weather permitted, I ſhould have ſown immediately upon ſpreading the aſhes. About the beginning of Auguſt the lentils were cut, and the other heap of aſhes was ſpread upon the ſurface; after which the land was plowed, and immediately ſown with turnip-ſeed. The turnips were well hoed, and produced an exceeding good crop. Being late ſown, they conſequently kept later in the ſpring than ſuch as were ſown at the uſual ſeaſon.

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* By A. St. Leger, Eſq.

From this mode of management, I dare ſay that no land was ever in a better ſtate for the Norfolk courſe of crops—of all others the moſt rational and profitable. But as my deſign is only to give the beſt method of preparing land for ſowing lucern broad-caſt, I ſhall drop any obſervations upon the propriety of the Norfolk huſbandry, viz. turnips, barley, clover, and wheat. The exact eſtimate of the expence incurred by my management is as follows:

	l.	s.	d.
Two years rent, — —	1	8	0
Mowing and getting the hay,	0	7	0
Carried over,	1	15	0

	l.	s.	d.
Brought over,	1	15	0
Paring and burning, ——	1	10	7½
Plowing three times, ——	1	4	0
Harrowing, —— ——	0	5	0
Gathering the aſhes into heaps,	0	15	0
Spreading ditto, — —	0	10	0
Lentil and turnip ſeed, ——	0	15	0
Mowing and getting the lentils,	0	9	0
Hoeing turnips, — —	0	7	0
	7	10	7½

	l.	s.	d.
Produce of hay, — —	6	0	0
Ditto of lentils, — —	4	0	0
Value of turnips, — —	3	0	0
	13	0	0
	7	10	7½
Profit,	5	9	4½

In May, 1773, I ſowed the field, broad-caſt, with lucern-ſeed, after being properly plowed and harrowed. The quantity of ſeed twelve pounds per acre, which I recommend to be ſown at twice, in order that the ſeed may be the more equally diſtributed upon the ſurface. Every time that the lucern is cut, the land muſt be run over by the harrows, to tear up the graſs and weeds that otherwiſe would eat out the lucern. The year after ſowing, the plants ſhould be hand-weeded, being then very tender; but the ſucceeding years, when the roots have firmly penetrated the ſoil, the heavieſt harrows may be introduced, without a poſſibility of injuring the plants.

After the froſts are over, and vegetation begins, the lands may be harrowed, if foul; but if clean, that operation will not be required till after the firſt cutting. At this preſent time, (Auguſt 1775) I am cutting the third crop, and expect another cutting this ſeaſon. With the above preparation of the land, and a proper attention to the lucern after being ſown, there is no doubt but that this foreign graſs will be a means of improving the Britiſh Huſbandry, by liberally ſupplying our cattle with green forage of a moſt lxurious and nouriſhing nature.

EXPERIMENT XXXVII.

On tranſplanting Potatoe Tops.

On the 18th of May, 1772, finding ſome beds I had ſown very early with onions to be a miſſing crop, I was induced to make the following experiment. The year before, I had ſet ſome potatoes in another part of my garden, in the common way; and as it is impoſſible but ſome will remain in the ground all winter, ſo I found a number of ſprouts about three inches high, which I nipped off cloſe to the ground, and tranſplanted them into the onion-beds, without any further preparation, about a foot and a half aſunder, in the ſame manner that cabbages and cauliflowers are planted. As the ſeaſon became immediately very dry, I was obliged to give my plants a little water for four or five ſucceſſive nights; after which they began to flouriſh, and had the appearance of a promiſing crop during all the ſummer. At the uſual time, in October, I ordered them to be taken up; and for ſize, quantity, and quality, they exceeded all I ever had in the common way. Had the ground been freſh, properly manured and prepared, and the plants put down at a proper diſtance from each other, I am of opinion that the ſucceſs would have been ſtill greater.

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* By Mr. Elleray, near Mancheſter.

EXPERIMENT XXXVIII.

On nutritive Lime.

Take ſixteen buſhels of ſlaked lime; train-oil-foot, ſixteen gallons. Mix theſe together, taking care that the lime be ſufficiently cold before the oil be added. This quantity is thought ſufficient for an acre of winter or ſpring corn. It is intended to ſupply the place of rape-duſt, and ſhould be put upon the land in the ſame manner. It may alſo be recommended as a top-dreſſing for wheat in the ſpring; the earlier the better. From the few trials that have been made upon this compoſt, it appears to be poſſeſſed of conſiderable nutritive powers; but as nothing ſhould be adopted as a truth, in agriculture, which has not ſtood the teſt of numerous trials, the above compoſt is recommended as an object worthy of future experiment. It is alſo recommended to gardeners as a top-dreſſing for all kinds of ſeeds, as it is preſumed that it will prevent the miſchiefs occaſioned by inſects.—By the experiments of Mr. Townley, of Belfield, near Rochdale, the oil-compoſt is found to be of great uſe in raiſing large crops of onions. This nutritive lime being upon the ſame principles, and much eaſier of preparation, will probably anſwer the ſame purpoſes. It will here be proper to remark, that light ſoils are beſt managed by top-dreſſings. Stiff lands require lime and plenty of rotten dung to break the coheſion of their particles.—This diſtinction ſhould be ſeriouſly attended to by the cultivators of land, who wiſh to enlarge their underſtandings by tracing effects up to their proper cauſes.

EXPERIMENT XXXIX.

On feeding Hogs with Potatoes [*].

From an accurate experiment made laſt year, I dare venture to recommend baked potatoes as an excellent food for hogs. The pork produced by this food, was equal to that from barley and beans; but at preſent I cannot exactly aſcertain the comparative experiment with regard to expence; however, I am of opinion that roaſted potatoes, conſidering the improvement of the hogs, is as cheap a food, if not cheaper, than can be given them. I roaſt my potatoes upon a kiln, ſimilar to what is uſed by oat-meal ſhellers for drying their oats. The difference in expence between boiling and roaſting the potatoes is prodigious, both with regard to the labour and fuel. A kiln that will coſt 3 l. will roaſt potatoes ſufficient for the maintenance of more than 20 hogs; and one man will beſtow all the neceſſary attendance upon them, and do other work beſides. The action of the fire, by diſſipating the crude juices that are contained in raw potatoes, reduces them into a ſtate highly wholeſome and nutritious. Boiling does this in part, but not ſo effectually. A potatoe roaſted in the manner above deſcribed, partakes much of the nature of a cheſnut, and perhaps is not greatly inferior to it.

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[*] By Mr. Charles Chaloner.

EXPERIMENT XL.

A Compariſon between Red and White Wheat *.

It is a miſtaken notion in thoſe who buy wheat for family uſe, to give the preference to the white ſort, it being a demonſtrable fact, that the red is conſiderably heavier. It is moreover of ſuch a ſtrong body, that provided you weigh 100lb. of the flour made from white wheat, and 100lb. from red wheat, the latter, by taking a greater quantity of water, will make a larger weight of bread. This circumſtance is known to few, except bakers and corn-dealers, who, in many of the country markets, buy the red wheat at 8d. and ſometimes 1s. per buſhel under the price of the white and weaker kind.

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* By Mr. E. Cleaver, of Whitwell, near York.

EXPERIMENT XLI.

On the beſt Method of raiſing Early Potatoes *.

As the culture of potatoes, and particularly of the early ſorts for the table, has of late become an object of very general attention, I hope the following account of a new method of obtaining theſe (without the help of hot-beds) will be acceptable to the public.

On the 2d of January, 1772, I made a hotbed for the forward ſort of potatoes, and on the 7

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* By Mr. M. Kirk, of Wilderſpool, near Mancheſter.

7th put in the ſets, placing a glaſs and frame over them, and taking every precaution to defend them from the froſt. Of theſe ſmall potatoes, or ſets, there remained about forty in a baſket, which was accidentally hung up in a warm kitchen, and there remained unnoticed till about the 25th of April. I then accidentally obſerved the baſket, and perceiving ſomething green on the edge of it, took it down, and, to my great ſurprize, found that the potatoes had ſprouted half a yard in length, and that there were a great number of very ſmall potatoes formed on the fibrous roots which had grown out. I took them into my garden, and planted them in a rich ſandy ſoil, without any manure. The roots I put into the ground three inches deep, and laid down the ſtems that had ſprouted, horizontally, and covered them with two inches of ſoil, but left the tops uncovered. Without farther attention they grew ſurprizingly.

On the 26th of May, I took up the roots planted in the hot-bed on the 7th of January. They by no means anſwered my expectations, or paid for the trouble of their culture: But at the ſame time, I was aſtoniſhed to find the others, which were put into the ground ſo late, to have produced larger potatoes than the roots in the hot-bed. I took up all the roots, and picked off the large potatoes from them, which amounted to from 4 to 12 on each root, and then ſet the roots again on the ſame ground. This, indeed, I have ſucceſsfully practiſed for many years, ſometimes even twice, and have had a good third crop at Michaelmas. When this method is tried, the roots muſt be watered on the evenings of hot days.

In January, 1773, in order to make a ſecond trial of this experiment with a large quantity, I placed a great many potatoes of the early ſorts on a thick layer of gravelly ſoil, cloſe to each other, over an oven, ſlated over, but open to the ſouth-weſt, and covered them two inches deep with the ſame earth.

At the end of April I took them up, and found the ſtems about a foot long or more. For fear of injuring the fine and delicate fibres of the roots, I took great care in taking them up, and planting them in the ſoil. This I now manured, but in all other reſpects treated them in the manner above deſcribed, many of the fibrous roots having then potatoes formed upon them, nearly as large as walnuts. For a week the plants came on ſurprizingly, when, by one ſharp night's uncommon froſt, they were nearly deſtroyed. However, notwithſtanding this, freſh ſtems grew up in a few days, and I actually gathered from them, on the 3d of June following, finer potatoes than were ſold at that time, at Mancheſter, from 1s. to 1s. 6d per lb. being the produce of hot-beds.

After taking off the larger potatoes, I again planted the roots for a ſecond crop, and in September obtained a very large produce. I weighed the increaſe of many ſeparate roots, which amounted from 4lb. 8oz. to 14lb. 12oz. the potatoes being the largeſt of the forward kinds I ever ſaw.

EXPERIMENT XLII.

On Lime *.

From the repeated ſucceſs I have had in liming of land, I am induced to relate an experiment which I am convinced may be attended with as much public utility as it has been productive of my own private advantage.

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* By Mr. E. Cleaver, of Whitwell, near York.

In the year 1765, I plowed up a piece of lean ſwarth, containing 18 acres, which, to all appearance, had it been ſown with oats, would not have produced above 3 quarters per acre. The quality was a wet, cold clay, not very ſtiff, but ſpungy, and worth about 10s. an acre, tithe-free. It will be proper to mention, that, in the time of the diſtemper amongſt the cattle, it was under the plow, and continued in tillage till it would ſcarce bring the ſeed again; after which it was ſuffered to lie down without either graſs-ſeeds or manure, and conſequently had no chance to improve but by reſt and length of time.—This, as near as I can deſcribe, was the quality of the land.

My courſe of huſbandry was as follows: Early in the ſpring I plowed it out of ſwarth, and laid on 167 chaldrons of lime, 32 buſhels, upheaped, to the chaldron. The whole was laid on immediately after the firſt plowing, or as ſoon as I could get it burnt and led to the land. After being four times plowed, and well harrowed between each plowing, I ſowed the whole 18 acres with rape. From the leanneſs and toughneſs of the ſwarth, I could not get it into proper order; ſo that towards the time of ripening the ſeed, rapes put up in the places where the crop was thinneſt, and did me conſiderable damage. I have obſerved that I laid on 167 chaldrons of lime upon the whole 18 acres, which is at the rate of 9½ per acre; but as I had a deſire to know the effect of the lime in different proportions, I divided the field into two unequal portions, N°. 1. and N°. 2. On N°. 1. (7 acres) were laid 84 chaldrons, which is 12 chaldron per acre; on N°. 2. (11 acres) were laid only 83 chaldrons, which is about 7½ chaldrons per acre.

The acreable Produce for three Crops.

N°. I.	l.	s.	d.
1770. Rape, (4 plowings) 32 buſhels, at 20l. per laſt,	8	0	0
1771. Wheat, (1 plowing) 50 ſtooks, or 40 buſhels, —	12	0	0
1772. Oats, (1 plowing) 68 buſhels; but would have been more had not the harveſt proved remarkably wet, whereby one fourth of the crop, at leaſt, was loſt, —— ——	5	19	0
Produce of 3 crops,	25	19	0

N°. II.	l.	s.	d.
1770. Rape, (4 plowings) 24 buſhels,	6	0	0
1771. Wheat, (1 plowing) 32 ditto,	9	12	0
1772. Oats, (1 plowing) 68 ditto, —	5	19	0
Produce of 3 crops,	21	11	0

	l.	s.	d.
Produce of N°. 1.	25	19	0
Ditto of N°. 2.	21	11	0
Difference in 3 crops,	4	8	0

It muſt here be remarked that the oats on this part were cut firſt, and did not receive ſo much damage by the wet ſeaſon as N°. 1. otherwiſe they were not near ſo ſtrong.

As I burn my own lime, it does not coſt me above 7s. 6d. per chaldron; ſo that the whole 12 chaldrons are paid for in three crops by the extraordinary produce, and the land left in better condition by three or four ſhillings per acre.

I would not have it underſtood that all land can bear an equal quantity of lime with what I have here mentioned. Whoever tries the experiment on old tilled land will find himſelf in an error, eſpecially if the ſoil be clay, which is apt to be too much bound after the fermentation of the lime is over—but ſand lands can never be over-done with lime, provided it be laid on in the ſpring, and not of that fiery kind which many of the ſorts are. Lime differs in quality as well as land itſelf. In many countries the crops would be burnt up if two chaldrons were laid on an acre; whereas in Derbyſhire there are inſtances of people laying on 12 and 14 chaldrons per acre on graſs land.

As this quantity of lime exceeds any experiment I have heard of in this country, I am apprehenſive the farmers in general will not give credit to it; however, I atteſt it as a fact; and as it is a thing of much conſequence, I ſhall have a particular pleaſure in having it confirmed by ſimilar experiments.

EXPERIMENT XLIII.

On preparing Seed-Wheat with Oil *.

The autumn of the year 1770 being remarkably wet, and a bad time for ſowing wheat, whereby

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[*] By Mr. E. Cleaver, of Whitwell, near York.

whereby many acres of land could not be converted to the intended purpoſe, but were obliged to be cropped with oats or barley in the ſpring, I was induced, through the proſpect of a great ſcarcity of wheat, to ſow down five acres of land at Candlemas, after eating off a crop of turnips with ſheep; and as the ſeaſon continued extreamly unfavourable I had recourſe to the following preparation of my ſeed, with a view to counteract the wetneſs of the ſeaſon: I put a pint of fiſh oil, and 3 lb. of ſalt, to every buſhel of ſeed; and as the birds at that ſeaſon would of courſe be troubleſome, I ſowed three buſhels and a half of ſeed to the acre. I had a further reaſon for beſtowing this *additional*, or rather *extraordinary* quantity of ſeed, which was, that the thicker the corn came up, the leſs it would gather, and conſequently would ripen quicker. My ſeed was the common Red Lammas, which is the hardieſt as well as the heavieſt ſort. The produce was 245 ſtooks (or 45 ſtooks to the acre) which yielded as follows:

	B.
30 ſtooks, threſhed out at Michaelmas, produced —	30
30 ditto at Candlemas, ——	27
30 ditto in May, —— —	24
	81

From the computation of 90 ſtooks to 81 buſhels, the whole crop of 245 ſtooks would yield 220½ buſhels, or 44 buſhels to the acre. The ſtraw was about 24 thraves per acre, and ſold ſo high as 1 s. 6 d. per thrave, which is 1 l. 16 s. per acre, though the average price of ſtraw, in this country, is not 1s. per thrave.

Value.		l.	s.	d.
44 buſhels, at 6 s. each,	—	13	4	0
24 thraves, at 1s. 6 d. each,	—	1	16	0
Per acre,		15	0	0

From the experiment of the proof of the corn by the ſtook, it plainly appears that, between Michaelmas and May-day, the farmer loſes in meaſure 6 buſhels in 30, or $\frac{1}{5}$ part, by the mere pining of the grain.

I find this method of ſteeping ſeed-corn in oil was formerly practiſed by the Romans.

> Semina vidi equidem multos medicare ſerentes,
> Et nitro prius, et nigrâ perfundere amurcâ,
> Grandior ut fœtus ſiliquis fallacibus eſſet.
>
> Virg. Georg. lib. i. l. 193.

There is reaſon to believe that this proceſs of oiling the ſeed will be found highly ſerviceable in wet ſeaſons, and perhaps at all times may contribute to the enriching the farina of the grain, which we know, from experiment, conſtitutes the nouriſhment of the tender germ.

EXPERIMENT XLIV.

On Dibbling Wheat *.

It is now become very common in the county of Norfolk to dibble their wheat inſtead of drilling, or ſowing it broad-caſt. The advantages of this method are numerous. It ſecures a clean crop of excellent ſeed, and ſaves to the community an enormous quantity of wheat, that inevitably muſt have been conſumed and loſt in the common method. It beſides finds employment for the women and children, at a time when their aſſiſtance is not required by the farmer for other purpoſes. Their labour is therefore a clear gain to the public. It has been objected, that if this method ſhould become general, the farmer could not procure hands to put his work ſufficiently forward. I readily grant that the villages could not ſufficiently ſupply the neceſſary hands, but it ſhould be conſidered, that, where work is certain, numbers of people are invited from towns and other remote diſtances. I need produce no arguments, after mentioning the facility with which hands are procured for the gathering ſaffron and hops. Previous to ſetting the wheat, the land muſt be plowed and manured as for a crop of broad-caſt grain. After harrowing it well, and ſmoothing the ſurface with a light roller, it is prepared for ſetting, which is performed by making holes with a kind of dibble uſed for peaſe, the man working backwards, and the women and children following, and dropping two or thre grains of wheat into each hole. The dibbles are ſo contrived, that a man may, with one ſtroke of his foot, make three or four holes at once—the holes about ſeven inches aſunder, and two inches deep. After the whole ground is ſet, a light harrow muſt be introduced to fill up the holes; and when the weeds advance, ſome turnip-hoers muſt be employed to ſtir the ground and cut down the weeds; after this no further care is required till the harveſt, when the farmer may be aſſured of a plentiful and clean crop in reward for his extraordinary attention. Two pecks of wheat will ſet an acre; the price of labour about eight ſhillings.

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* By John Curzon, Eſq.

EXPERIMENT XLV.

On Claying Land *.

Where the land has never been broke up, the clay may be carried and ſpread, and ſuffered to lie a whole year before it is plowed in. The flag will ſet the clay a-working; but where there is no flag, a coat of dung will be neceſſary before the land is ſown. Where the clay is ſhort, and the ſoil light, 120 loads will be required for an acre; but where the clay is ſtrong, and the land not ſo light, then 60 or 80 loads will be ſufficient. It is better to lay on too little than too much; it will be ſufficient if the land is made moderately cloddy. About a cubical yard of clay makes a load. Carry the clay at any convenient time of the year. If time permit, carry it after harveſt, and lay it upon a wheat ſtubble; there let it remain ſpread all the winter. In March plow it in; again in May, and twice in June, and ſow turnips about Midſummer. In Norfolk they formerly paid one guinea for filling and ſpreading 120 loads of clay, but now (1772) they are obliged to allow ſomething more.

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* By the Rev. Mr. Buxton, Norfolk.

EXPERIMENT XLVI.

On Siberian Barley *.

It is not yet determined what kind of land is moſt ſuitable for the cultivation of Siberian barley. From the weight of the grain, it would ſeem that it requires good rich land; and indeed my experiment, when compared with others made upon poor land, ſeems to me very deciſive in favour of a rich ſoil. In the firſt week of April, 1774, I plowed half a rood of land that the year before had borne a crop of cabbages, and ſowed it with a buſhel of Siberian barley. The ſoil a rich hazel earth. The crop was reaped before the common barley. The product ſeven buſhels.

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* By Mr. Wright, of Craike.

ESSAY V.

On the Sexes of Plants.

WHEN we unfold the volume of nature, the human mind may very juſtly be compared to a bee unable to ſettle amidſt a variety of ſweets. Every page preſents us with a ſubject inexpreſſibly pleaſing, and every object fills us with admiration as well as delight. We are at a loſs to acknowledge the exiſtence of a ſupreme Being, or the benign influence of that Being in providing for the happineſs and convenience of his creatures, in ſtronger terms.

Every perſon who takes a view of nature in this light, muſt undoubtedly conclude, that as the wants and conveniences of life were deſigned to be ſupplied from the ſtore-houſe of nature, from the very moment that man ſtarted into exiſtence, ſo the means for executing that deſign on the moſt advantageous terms, muſt be a laudable as well as neceſſary undertaking.

Man, above all other creatures, is bleſſed with a power of improving his underſtanding, and his actions, to an amazing degree of perfection. And he that is deſirous to drink clear water, rather than muddy and corrupted, uſually neglects the diſtant ſtream, and prudently repairs to the fountain head, where the element flows pure and unadulterated.

In arts and ſciences, the practical part will be conducted upon a vague and uncertain plan, till the theoretical be founded upon rational and conſiſtent principles. The œconomical part of nature depends much upon the phiſiological; and even in common life, cauſes muſt ever be prudently adjuſted, if we expect their conſequences to be pleaſing. It is this that has led on ſcience, through the different periods of time, to the height ſhe has now arrived at; and it is this that, in future ages, will render the improvements of the preſent æra, admired, careſſed, and imitated.

The preſent century is very remarkable for its various improvements in natural hiſtory, among which agriculture deſervedly claims the foremoſt rank. And ſince agriculture has been reduced to a regular ſcience, and its principles eſtabliſhed upon facts and experiments, it has made a commendable and extenſive progreſs. We every day experience the moſt pleaſing effects from the induſtry of men of literature and ingenuity, who are continually taking up the pencil to fill up the outlines of ſo grand a deſign. Much has already been done, and yet a great deal remains to be executed. Nature unfolds not all her treaſures at once, but is ſlow and gradual in her operations. The hyacinth and the tulip require the warmth of many revolving ſuns to produce their inimitable beauty and attire!

The labours of the great Linnæus can never be ſufficiently admired; and his endeavours to new-model the ſtudy of nature, have already exceeded the moſt ſanguine expectation. He has ſketched out the philoſophy of nature ſo ſtrongly, that he is every where conſidered as the wonder of his age. The ſubject of this eſſay, in particular, owes much to his penetration; and though he does not claim the ſole merit of diſcovering the ſexes of plants, yet he deſerves our utmoſt acknowledgments for having brought all the arguments in favour of it into the cleareſt point of view. It is now a truth too glaring to be denied.

We find that the ancients were by no means ſtrangers to the notion of the ſexes of plants; and though their writings do not bear any very ſtrong evidence in their behalf, yet their obſervations and their practice clearly demonſtrate it. They appear to have been perfectly ſatiſfied that nature purſues the ſame plan of preſerving the ſpecies in the vegetable, as in the animal world: That male and female are as diſtinct in the one kingdum as the other, and that they are governed by ſimilar laws.

Herodotus tells us that the Babylonians, in cultivating the Palm-tree, with which their country was plentifully ſtored, were forced to gather the flowers of the male tree, and carry them to the female, if they expected to reap any fruit; but their notions went no further than the cuſtomary practice. Theophraſtus, in his hiſtory of plants, obſerves that ſome kinds of trees were diſtinctly male and female, and ſtrengthens his ſuppoſition by adding that the one bore fruit, and the other was barren.

It is amazing that nothing material ſhould have been ſtruck out upon the ſubject from Theophraſtus's time till Sir Thomas Millington, Savilian Profeſſor of Aſtronomy at Oxford, towards the cloſe of the laſt century, revived the notion, and cleared the way for the experiments of the celebrated Grew. Since that time many able naturaliſts have diſcuſſed the point with clearneſs and preciſion, among whom our illuſtrious countryman, Mr. Ray, appears with Camerarius, Moreland, Geoffroy, Vaillant, Blair, Bradley, and others.

This new doctrine met with ſome conſiderable opponents. Monſieur Tournefort was a violent adverſary; and Dr. Alſton, the late Profeſſor of Botany at Edinburgh, muſtered all his forces in the oppoſition.

The critical reader will be much pleaſed with the anatomical deſcription of the parts of flowers, and the nice diſſection of their organs of generation, in Grew's Anatomy of Plants, Linnæus's Philoſophia Botanica, and in the Sponſalia Plantarum in the firſt volume of the Amænitates Academicæ, to which I refer him. But however obvious the ſexes of plants may appear in ſome claſſes in the *ſame* flower, in others in *different* flowers, and in others upon *different* plants, yet I fear the peculiar mode of operation, by which nature ultimately effects her generations in the vegetable world, will continue a ſecret ſo long as the theory of *animal* conception remains undetermined. All that ſeems uſeful to us is already diſcovered; and let man, the finite creature of an hour, leave the reſt to the Author of Nature to diſcloſe, by thoſe gentle degrees which always terminate in ſome unforeſeen bounty and munificence.

In the 47th volume of the Philoſophical Tranſactions there is a letter from Mr. Mylius of Berlin, dated from thence February 20, 1750-51, to Dr. Watſon, which was preſented to the Royal Society by the Doctor in the ſucceeding year, and publiſhed by him, with his own obſervations, in the Tranſactions. It contains a proof of the ſexes of plants, from an experiment made on the Palm-tree. The ſingularity of the Experiment will apologize for its appearance in this eſſay.

"The ſex of plants is very well confirmed by an experiment that has been made here on the *Palma Major foliis flabelliformibus.* There is a great tree of this kind in the garden of the Royal Academy. It has flowered and borne fruit theſe thirty years, but the fruit never ripened, and when planted it did not vegetate. The Palm-tree, as you know, is a *Planta Dioecia*, that is, one of thoſe in which the male and female parts of generation are upon different plants. We having no male plants, the flowers of our female were never impregnated by the *farina* of the male. There is a male plant of this kind in a garden at Leipſic, twenty German miles from Berlin. We procured from thence, in April 1749, a branch of male flowers,

ers, and ſuſpended it over our female ones; and the experiment ſucceeded ſo well, that our Palm-tree produced more than an hundred perfectly ripe fruit; from which we have already 11 young Palm-trees. This experiment was repeated laſt year, and our Palm-tree bore above two thouſand ripe fruit. As I do not remember a like experiment, I thought it convenient to mention it to you; and if you think proper, be pleaſed to communicate it to the Royal Society."

A perſon who is a *ſtranger* to natural, and more particularly to botanical knowledge, may make himſelf an entire maſter of what is meant by the ſexes of plants, and form an accurate idea of the mode of generation, in the groſs, whoſe garden produces a ſingle tulip. When the flower opens, if he looks within the leaves, or, to ſpeak in the language of botaniſts, with in the *petals*, there will be found ſix ſlender erect chives, or *ſtamina*, ſurrounding a three-ſquared ſtronger body, called the *pointal*, or female part of the flower. Upon the top of each of the *ſtamina* hangs a ſmall oval body, which, in a day or two after the flower is blown, may be obſerved to burſt into a mealy ſubſtance. This meal, or *farina*, is the male part of the flower, and by the action

tion of the wind is blown upon the *pointal*, or female part of the flower, which is furniſhed with a viſcous kind of matter, deſigned by nature to retain the male *farina* when blown upon it. From this moment the impregnation takes place, and the ſeed is produced perfect and entire.

As a further proof of the neceſſary influence of the male *farina*, only pinch off the male part of the flower before the *farina* begins to burſt out, and the female part will, at the uſual time of expecting the ſeed, preſent the examiner with nothing but an abortive ſeed-veſſel.

In moſt vegetables the male and female organs of generation appear in the *ſame* flower; but in ſome plants there are male and female flowers on *ſeparate* parts of the ſame plant; and in other plants, the male flower appears on *one* plant, and the female on *another*.

From theſe premiſes, the improvers of agriculture, and even the common practical farmer, may be able to deduce very uſeful conſequences. If the farmer dreads heavy and ſudden rains, immediately after he has ſown his ſeed, he may, with equal reaſon, be afraid of them at the time his corn is in bloom. For, as the wet will injure him in one caſe by burſting the ſeed, ſo it will in the other by waſhing off the *farina*, or male duſt, whereby an effectual impregnation will be prevented. The farmer will not then be ſurprized if his grain appears ſmall and pined at the time of threſhing, when he can ſo readily account for the cauſe in philoſophic terms.

But the principal uſe that will accrue to the gardener and the farmer from the diſcovery of the ſexes of plants, will be the hints they may gain in regard to ſaving the different kinds of grain for ſeed. It is always an object with the judicious cultivator to throw fine bold ſeed upon the earth, if he expects the produce to gain him credit in the market. And certainly if the winds have ſuch an effect upon the *farina* of flowers, as not only to waft it upon the female flowers of the *ſame* ſpecies, but even upon *different* ſpecies, care ſhould be taken that the ſeveral kinds of grain, if deſigned for ſeed, be ſown at as great a diſtance from each other as poſſible, to prevent the ill conſequences of a *mongrel* produce.

Mr. Miller, in his Gardener's Dictionary, preſcribes this caution to the cultivators of cabbages, cauliflowers, turnips, brocoli, &c. in very ſtrong terms. For if they expect the ſeveral kinds to be perfect, theſe plants muſt by no means be ſet near each other when deſigned for ſeed, becauſe, in that caſe, the *farinas* will undoubtedly incorporate, and produce a *baſtard*, or imperfect kind of each ſpecies. Mr. Ray, in his Hiſtory of Plants, tells a remarkable ſtory of a gardener, one Richard Baal, of Bramford, who had ſold cabbage-ſeed to the London gardeners as of an excellent kind, but unluckily, when ſown and cultivated by them, produced an exceeding bad kind. The conſequence was, that the man was proſecuted in the courts of juſtice at Weſtminſter, and ſentenced to return the money he had taken for the ſeed, and alſo to ſatisfy his cuſtomers for their waſte of ground, time, and labour; though, in fact, he was not at all deſerving of ſuch a ſentence, not having had the leaſt deſign to impoſe upon them.

Nothing is ſo common as for gardeners in the raiſing of melons and cucumbers, at the time of the flowering of thoſe plants, to pinch off what they call the *barren* flowers, leſt the quantity of fruit ſhould impoveriſh its ſize. But for want of knowing that theſe plants produce male and female flowers *ſeparate* upon the ſame plant, and that no fruit can be expected unleſs there be a communication of the two ſexes, it is no wonder that their crops frequently fail.

It may not be amiſs to cloſe this eſſay, by pointing out ſome of the principal plants, in our own country, where the fructification varies from the uſual form.

1. Male and female flowers on the ſame plant. Linnæus's 21ſt Claſs, *Monoecia*.

The Carex tribe of graſſes.
Birch tree.
Alder.
Box.
Burnet.
Cheſnut tree.
Beech.
Hornbeam.
Haſel-Nut tree.
Firs.

2. Male and female flowers on ſeparate plants. Linnæus's 22d Claſs, *Dioecia*.

Willows.
Miſſeltoe.
Buckthorn.
Hops.
Black Briony.
Poplars.

Dog's Mercury.
Juniper.
Yew tree.
Knee-Holly, or
Butchers Broom.
Hemp.

3. Flowers hermaphrodite, and alſo male or female flowers. Linnæus's 23d Claſs, *Polygamia.*

Sycomore tree. Common Maple. Aſh tree.

ESSAY VI.

On a cheap and expeditious Method of draining Land.

FROM a very extenſive experience I recommend the following method of draining land, as effectual, durable, and cheap.

Firſt make the main drains down the ſlope or fall of the field. When the land is very wet, or has not much fall, there ſhould, in general, be two of theſe to a ſtatute acre; for the ſhorter the narrow drains are, the leſs liable they will be to accidents.

The

The width of the trench for the main drains ſhould be, at the top, about thirty inches; but the width at the bottom muſt be regulated by the nature and ſize of the materials intended to be uſed. If the drain is to be made of bricks ten inches long, three inches thick, and four inches in breadth, then the bottom of the drain muſt be twelve inches; but if the common ſale bricks are uſed, then the bottom muſt be proportionably contracted. In both caſes there muſt be an interſtice of one inch between the bottom brick and the ſides of the trench, and the vacuity muſt be filled up with ſtraw, ruſhes, or looſe mould. For the purpoſe of making theſe drains, I order my bricks to be moulded ten inches long, four broad, and three thick. Theſe dimenſions make the beſt drain; and I beg leave to be underſtood, throughout this eſſay, as ſpeaking of bricks formed in the above manner.

The method I purſue in conſtructing my main drains is as follows:

When the ground is ſoft and ſpungy, the bottom of the drain is laid with bricks, placed acroſs. On theſe, on each ſide, two bricks are laid flat, one upon the other, forming a drain

Fig 1

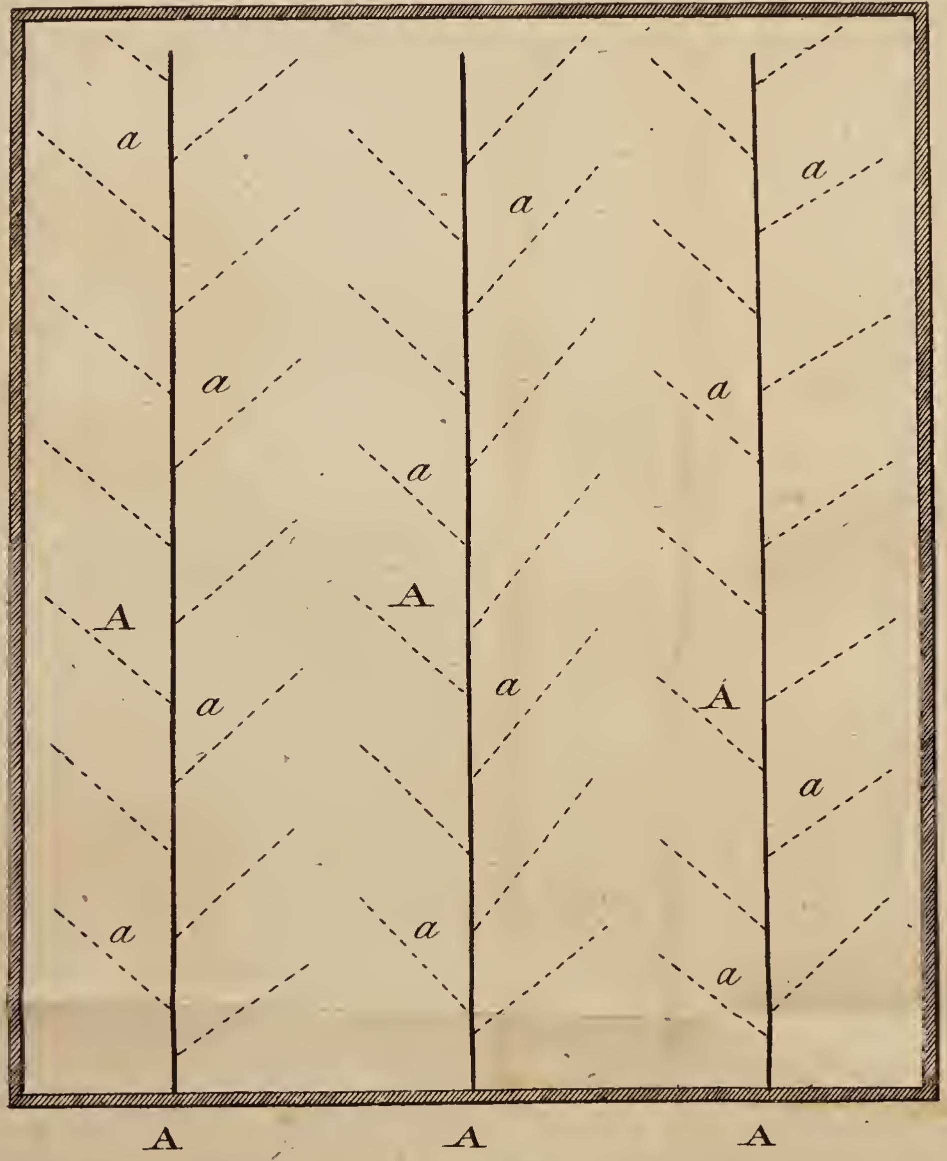


Fig. 2.

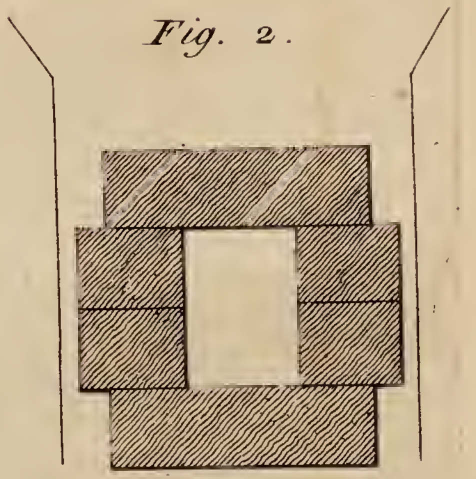


Fig. 4.

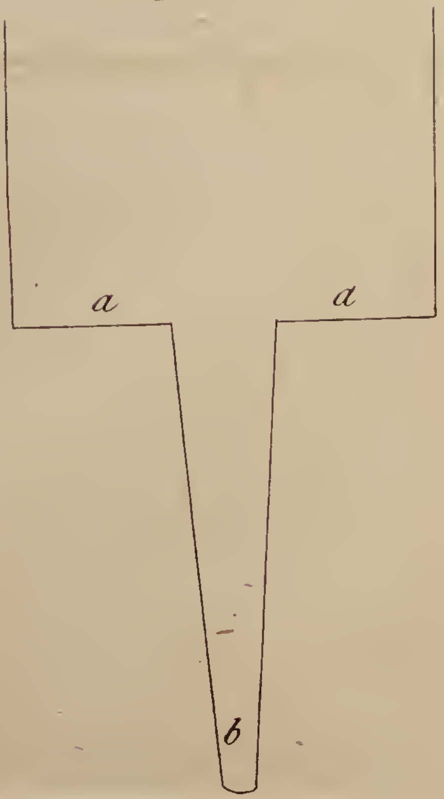


Fig 3.

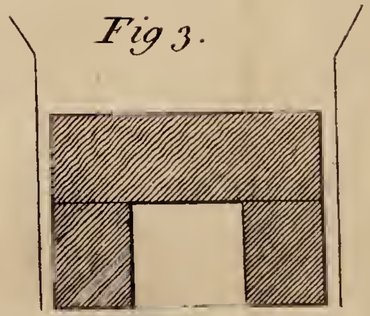
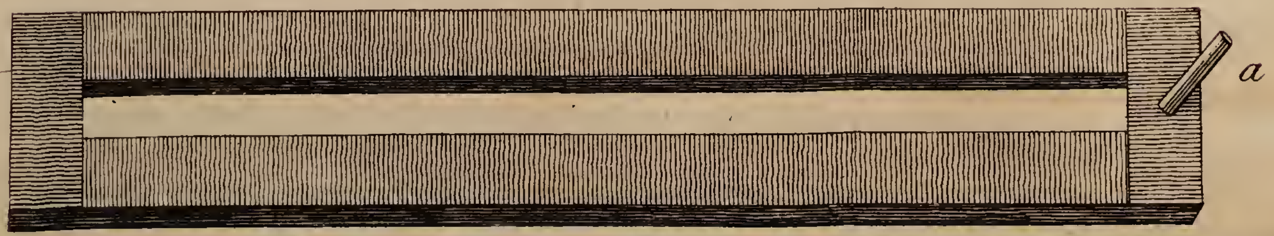


Fig. 5.



ſix inches high and four broad. This is covered with bricks laid flat. *Fig.* 2. *Plate* 2.

When the bottom of the trench is found to be a firm and ſolid body, as clay or marl, the bottom of the drain does not then require being laid with bricks. In that caſe the ſides are formed by placing one brick edgeways, inſtead of two laid flat. *Fig.* 3. *Plate* 2.

This latter method is much cheaper, and in ſuch land equally durable with the other. When *ſtones* are uſed inſtead of bricks, the bottom of the drain ſhould be about eight inches in width. And here it will be proper to remark that, in all caſes, the bottom of the main drains muſt be ſunk four inches below the level of the narrow ones, even at the point where the latter fall into them.

The main drains ſhould be kept open till the narrow ones are begun from them, after which they may be finiſhed: but before the earth is returned upon the ſtones or bricks, it will be adviſeable to throw in ſtraw, ruſhes, or bruſh-wood, to increaſe the freedom of the drain.

The ſmall narrow drains ſhould be cut at the diſtance of ſixteen or eighteen feet from each other, and ſhould fall into the main drain at very acute angles, to prevent any ſtoppage. At the point where they fall into, and eight or ten inches above it, they ſhould be made firm with brick or ſtone.

In making the narrow drains I employ four labourers. The firſt man, with a common ſpade, takes out the turf, or ſods, eighteen inches wide, (the drains being before marked out) and lays them carefully on one ſide; the ſecond man, with a common ſpade alſo, digs out two, three, or more ſpits of earth (laying it on the other ſide of the trench) till he has cut through the ſoil, or ſtaple, and come to the under-ſtratum of clay, marl, or other hard and ſolid body of earth. The bottom and ſides of this trench muſt be cleanly wrought; and, allowing for the ſloping of the ſides in working, ſhould, at the bottom, be clear ſixteen inches wide.

In this trench the frame, *Fig*. 5. *Plate* 2. is laid; and, in the middle of it, the third man, who ought to be the ſtrongeſt and moſt expert, works the long narrow draining ſpade in the body of the clay. By taking care to work it at its full depth, he is always ſure of his level, if the drains are properly laid out. The wooden frame is of great uſe; it gives a firm ſupport to the feet of the workman, keeps the bottom of the trench ſmooth and clean, and ſerves as a purchaſe to the wings of the narrow tool. *Fig.* 1, 2, 3, 4, 5. *Plate* 3.

When thirty or forty yards have been cut out by the draining ſpade, the fourth man cleans the bottom of the drain with the ſcoop, *Fig.* 6. *Plate* 3. and works it quite ſmooth; he then covers it with the ſods, laying the graſs ſide downwards. In this part of the work too much care and attention cannot be uſed. The ſods ſhould be ſound and dry, cut even on the ſides, and fitted cloſely to each other. No broken or rotten pieces ſhould be put in; and if any of the ſods taken out, in cutting the trench for the narrow drains, are bad, good ones, firm and full of roots of ruſhes, ſtrong graſs, &c. ſhould be got in the other parts of the field, and their place ſupplied with the decayed ones. In marſhy bad fields, where *ſound* turf cannot be had, little ſticks may be placed acroſs the trench, and the looſe and tender ſods ſafely laid upon them. The narrow drains being thus covered, the earth muſt be thrown in again, taking care that the clay, &c. brought out by the narrow tool, be not mixed with it. No greater length of theſe drains ſhould be cut than can be finiſhed the ſame day. The price varies with the depth. For the main drains cut thirty inches above, and thirty-eight deep, laid with bricks, covered, &c. I give about ninepence per rod (eight yards). For the narrow drains, conſtructed and compleatly finiſhed according to the foregoing directions, their whole depth (including that of the trench, and that of the draining ſpade) being thirty-two or thirty-four inches, I give fivepence halfpenny per rod (eight yards [*].)

From my much-reſpected friend, the Rev. Mr. Whateley, of Nonſuch-Park in Surry [†], I firſt received an account of the Hertfordſhire and Eſſex method of draining; at the ſame time he obligingly ſent me a ſet of the tools made uſe of there, with very particular directions.

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[*] At this price my labourers, after they were a little acquainted with the work, earned, even in winter, two ſhillings a-day each.

[†] Profeſſor of Rhetoric in Greſham College.

The great price of ſtone and brick in my neighbourhood rendered the Hertfordſhire method too expenſive. Hence I took the idea of the ſod drains, and the improvement of the tools. Mr. Young, in the ſecond edition of his juſtly-eſteemed *Six Months Northern Tour*, calls me the inventor of this method of draining. All the merit I claim is that of having introduced, together with an amendment of their conſtruction, the application of theſe celebrated tools to a mode of draining with ſods or turf, where ſtone, brick, or even bruſh-wood is extremely ſcarce and dear.

Wherever this is the caſe, I can, from my own experience, recommend the hollow drains covered in the above manner.

I muſt obſerve that, in looſe crumbly ſoils, where the wetneſs does not ariſe from the retention of water by an under-ſtratum of clay, but from ſprings, theſe drains are *improper:* For ſuch lands they ſhould be made of brick or ſtone. On the contrary, which is moſt commonly the caſe, when the wet is prevented from paſſing off by an under-ſtratum of clay, marl, or a mixture of both, theſe ſod drains are excellent.

For if the whole ſtaple or ſoil is cut through, as it ought to be, the narrow tool will be wholly worked in a ſolid body, and leave a firm compact ledge, or ſhoulder, of ſix inches wide on each ſide, for the ſod to reſt on. *Fig.* 4. *Plate* 2. The ſtrength with which the ſods are ſupported, and their depth in the ground, will effectually prevent their removal by any weight on the ſurface, and ſecure them from all effects of the weather. Being, at their leaſt depth, twelve inches below the ſurface, they will alſo be beyond the reach of the plow.

With reſpect to the ſhape of the narrow drains, it will be ſcarce neceſſary to obſerve, that their great depth and contracted width enable them to draw in the moiſture of the earth, and at the ſame time to keep themſelves clear and open.

The tools ſhould be formed of well-wrought iron, and made with great care and exactneſs. Including the ſhaft, the narrow tool ſhould weigh 12 lb.*

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* Theſe tools are made by Benjamin Royle, Smith, in Dole-field, Daneſgate, Mancheſter; and by William Staveley, Smith, in Stonegate, York.—Price 12 s.

References to the Plates.

Plate 2. *Fig.* 1. A field with the drains properly laid out. *A A A* the main drains; *a a a a* the narrow ſod drains.

Fig. 2. A brick drain.—Proper when the ground is wet and ſpungy.

Fig. 3. A brick drain.—Proper when there is a hard or clay bottom.

Fig. 4. A narrow drain; *a a* the ſhoulders for the ſod to reſt upon; *b* the cut made by the narrow ſpade. This, and *Fig.* 2 and 3, may be meaſured by the ſcale of *Plate* 3.

Fig. 5. The wooden frame to be laid in the trench. It is made of two oak boards, (inch thick) each twelve feet long and ſix inches in breadth. They are faſtened together at the ends by two ribs on the upper ſide, leaving a ſlit of five inches for the entrance of the narrow ſpade. *a* the handle.

Plate 3. *Fig*. 1. A front view of the narrow draining ſpade. *a* the ſhaft; *b* the wings for the workman's foot; *c* the iron part of the ſpade, which is gently concave.

Fig. 2. A ſide view. *a* the ſhaft; *b* the wings; *c* two ſharp fins, one on each ſide, for cutting the next ſpade graft; *d* the iron part.

Fig. 3. A back view. *a* the ſhaft; *b* the wings; *c* the cutting fins; *d* the iron part, which is convex.

Fig. 4. A back view in perſpective. *a* the ſhaft; *b* the wings; *c* the fins; *d* the iron part.

Fig. 5. A front view in perſpective. *a* the ſhaft; *b* the wings; *c* the fins; *d* the iron part. It will here be proper to remark, that the perſpective views muſt not be meaſured by the ſcale.

Fig. 6. The ſcoop. *a a* the wooden handle; *b* the iron ſcoop.

Fig. 4.

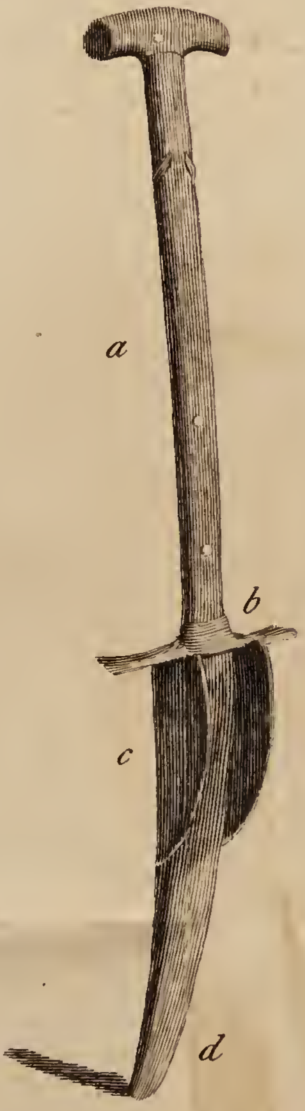


Fig. 1.

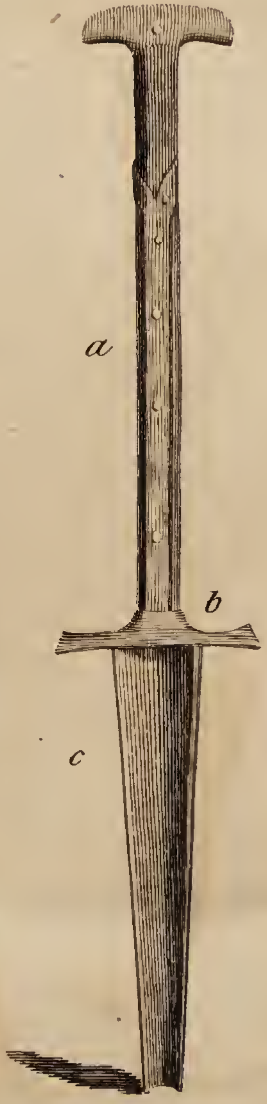


Fig. 2.

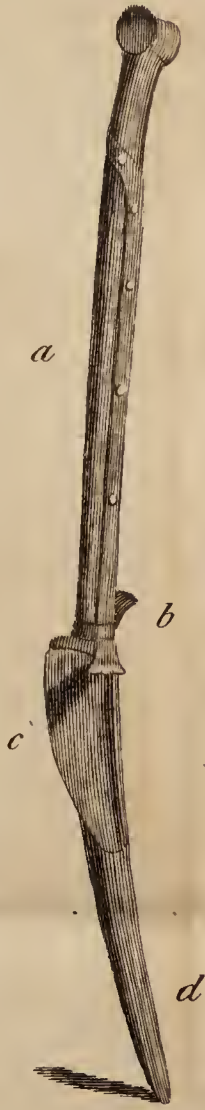


Fig. 3.

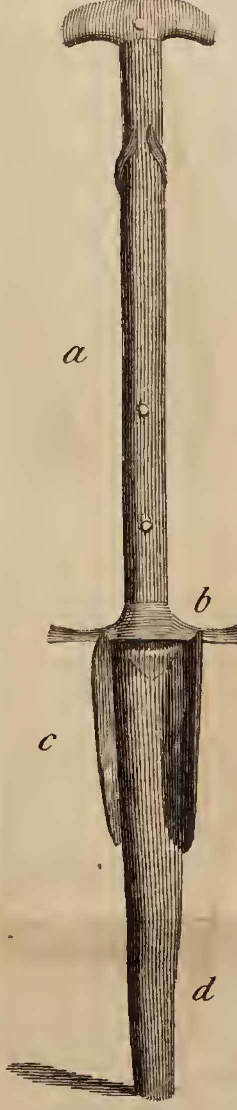


Fig. 5.

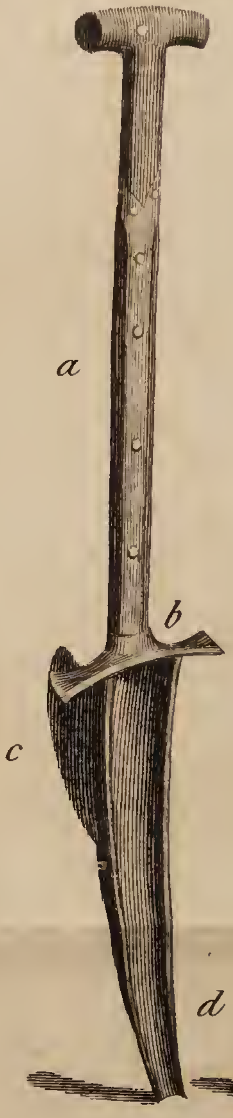
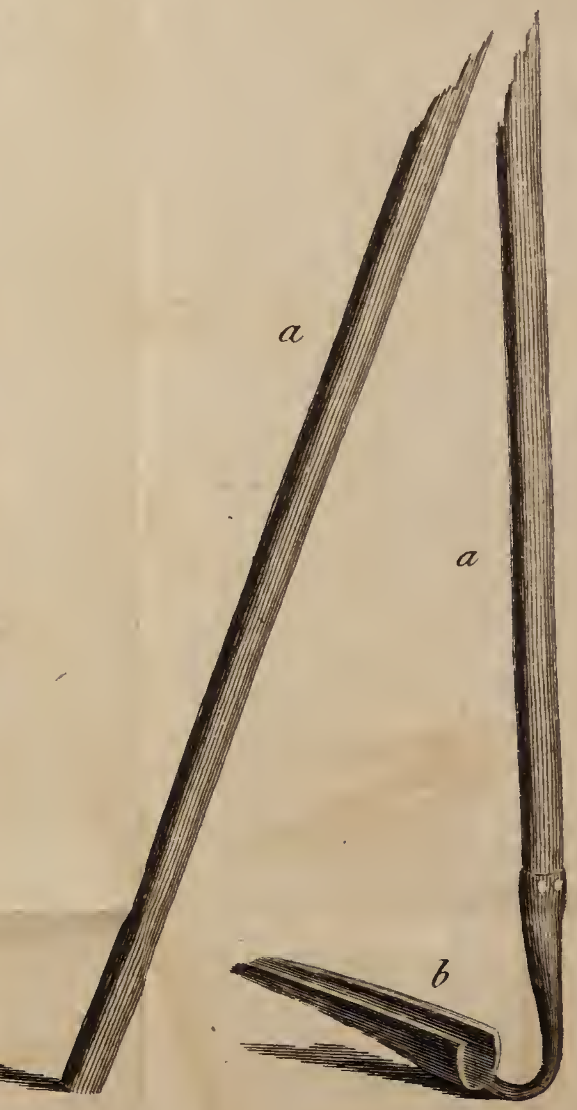
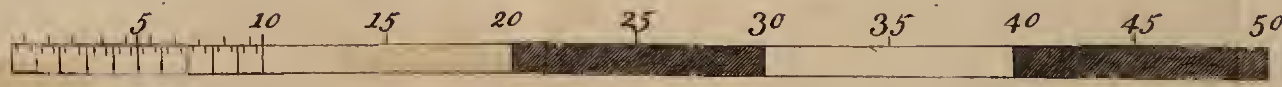


Fig. 6.





Scale of Inches.

ESSAY VII.

On the Preparation, Culture, and Uſe of the Orchis Root.

SALEP is a preparation of the root of Orchis, or Dogſtones, of which many ſpecies are enumerated by botanical writers. The *Orchis maſcula Linn. ſp. pl.* is the moſt valued, although the roots of ſome of the palmated ſorts, particularly of the *Orchis Latifolia*, are found to anſwer almoſt equally well. This plant flouriſhes in various parts of Europe and Aſia, and grows in our country ſpontaneouſly, and in great abundance. It is aſſiduouſly cultivated in the Eaſt; and the root of it forms a conſiderable part of the diet of the inhabitants of Turkey, Perſia, and Syria. A dry, and not very fertile ſoil is beſt adapted to its growth. An ingenious friend of mine, in order to collect the ſeed, tranſplanted a number of the Orchiſes into a meadow, where he had prepared a bed well manured for their reception. The next ſpring few of them appeared, and not one came to maturity, their roots being black and half rotten. The ſame gentleman informed me that he had never been able to raiſe any plants from the ſeed of the wild Orchis; but he aſcribes his want of ſucceſs to the wetneſs of the ſituation in which he reſides. I have now before me a ſeed pod of the Orchis, the contents of which, to the naked eye, ſeem to be ſeed corrupted and turned to duſt; but, when viewed through a microſcope, appear evidently to be organized, and would, I doubt not, with proper culture, germinate, and produce a thriving crop of plants. The propereſt time for gathering the roots is when the ſeed is formed, and the ſtalk is ready to fall, becauſe the new bulb, of which the ſalep is made, is then arrived to its full maturity, and may be diſtinguiſhed from the old one by a white bud riſing from the top of it, which is the germ of the Orchis of the ſucceeding year.

Several methods of preparing ſalep have been propoſed and practiſed. Geoffroy has delivered a very judicious proceſs, for this purpoſe, in the *Hiſtoire de l'Academie Royale des Sciences*, 1740; and Retzius, in the Swediſh Tranſactions, 1764, has improved Geoffroy's method. But Mr. Moult, of Rochdale, has lately favoured the public with a new manner of curing the Orchis root; and as I have ſeen many ſpecimens of his ſalep, at leaſt equal, if not ſuperior, to any brought from the Levant, I can recommend the following, which is his proceſs, from my own knowledge of its ſucceſs. The new root is to be waſhed in water, and the fine brown ſkin which covers it is to be ſeparated by means of a ſmall bruſh, or by dipping the root in hot water, and rubbing it with a coarſe linen cloth. When a ſufficient number of roots have been thus cleaned, they are to be ſpread on a tin plate, and placed in an oven heated to the uſual degree, where they are to remain ſix or ten minutes, in which time they will have loſt their milky whiteneſs, and acquired a tranſparency like horn, without any diminution of bulk. Being arrived at this ſtate they are to be removed, in order to dry and harden in the air, which will require ſeveral days to effect; or, by uſing a very gentle heat, they may be finiſhed in a few hours *.

Salep, thus prepared, may be afforded in this part of England, where labour bears a high value, at about 8 d. or 10 d. per lb. And it might be ſold ſtill cheaper if the Orchis

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* Vid. A Letter from Mr. John Moult to the Author, containing a new Method of preparing Salep.——Phil. Tranſact. vol. 59.

were to be cured without ſeparating from it the brown ſkin which covers it: A troubleſome part of the proceſs, and which does not contribute to render the root either more palatable or ſalutary. Whereas the foreign ſalep is now ſold at 5 or 6s. per lb.

The culture of the Orchis, therefore, is an object highly deſerving of encouragement from all the lovers of agriculture. And as the root, if introduced into common uſe, would furniſh a cheap, wholeſome, and moſt nutritious article of diet, the growth of it would be ſufficiently profitable to the farmer.

Salep is ſaid to contain the greateſt quantity of vegetable nouriſhment in the ſmalleſt bulk. Hence a very judicious writer, to prevent the dreadful calamity of famine at ſea, has lately propoſed that the powder of it ſhould conſtitute part of the proviſions of every ſhip's company. This powder and portable ſoup, diſſolved in boiling water, form a rich thick jelly, capable of ſupporting life for a conſiderable length of time. An ounce of each of theſe articles, with two quarts of boiling water, will be ſufficient ſubſiſtence for a man a day *; and, as being a mixture of animal and vegetable food, muſt prove more nouriſhing than double the quantity of rice cake, made by boiling rice in water; this laſt, however, ſailors are often obliged ſolely to ſubſiſt upon for ſeveral months, eſpecially in voyages to Guinea, when the bread and flour are exhauſted, and the beef and pork, having been ſalted in hot countries, are become unfit for uſe †.

But as a wholeſome nouriſhment, rice is much inferior to ſalep. I digeſted ſeveral alimentary mixtures prepared of mutton and water, beat up with bread, ſea biſcuit, ſalep, rice flour, ſago powder, potatoe, old cheeſe, &c. in a heat equal to that of the human body. In forty-eight hours they had all acquired a vinous ſmell, and were in briſk fermentation, except the mixture with rice, which did not emit many air bubbles, and was but little changed. The third day ſeveral of the mixtures were ſweet, and continued to ferment; others had

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* Portable ſoup is ſold at 2s. 6d. per lb. ſalep, if cultivated in our own country, might be afforded at 10d. per lb. the day's ſubſiſtence would therefore amount only to 2½d.

† Vid. Dr. Lind's Appendix to his Eſſay on the Diſeaſes of Hot Climates.

had loſt their inteſtine motion, and were ſour; but the one which contained the rice was become putrid. From this experiment it appears that rice, as an aliment, is ſlow of fermentation, and a very weak corrector of putrefaction. It is therefore an improper diet for hoſpital patients; but more particularly for ſailors, in long voyages, becauſe it is incapable of preventing, and will not contribute much to check the progreſs of that fatal diſeaſe, the ſea ſcurvy *. Under certain circumſtances, rice ſeems diſpoſed of itſelf, without mixture, to become putrid; for, by long keeping, it ſometimes acquires an offenſive fœtor; nor can it be conſidered as a very nutritive kind of food, on account of its difficult ſolubility in the ſtomach. Experience confirms the truth of this concluſion; for it is obſerved by the planters in the Weſt-Indies, that the negroes grow thin, and are

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* Cheeſe is now become a conſiderable article of ſhip proviſions. When mellowed by age, it ferments readily with fleſh and water, but ſeparates a rancid oil, which ſeems incapable of any further change, and muſt, as a ſeptic, be pernicious in the ſcurvy; for rancidity appears to be a ſpecies of putrefaction. The ſame objection may be urged, with ſtill greater propriety, againſt the uſe of cheeſe in hoſpitals; becauſe convaleſcents are ſo liable to relapſes, that the ſlighteſt error of diet may occaſion them. Vid. Percival's Letter to Mr. Aikin. Thoughts on Hoſpitals, p. 95.

are leſs able to work whilſt they ſubſiſt upon rice.

Salep has the ſingular property of concealing the taſte of ſalt water *; a circumſtance of the higheſt importance at ſea, when there is a ſcarcity of freſh water. I diſſolved a drachm and a half of common ſalt in a pint of the mucilage of ſalep, ſo liquid as to be potable, and the ſame quantity in a pint of ſpring water. The ſalep was by no means diſagreeable to the taſte, but the water was rendered extreamly unpalatable.

This experiment ſuggeſted to me the trial of the Orchis root as a corrector of acidity; a property which would render it a very uſeful diet for children. But the ſolution of it, when mixed with vinegar, ſeemed only to dilute, like an equal proportion of water, and not to cover its ſharpneſs.

Salep, however, appears, by my experiments, to retard the acetous fermentation of milk, and conſequently would be a good lithing for milk pottage, eſpecially in large towns, where the cattle,

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* Vid. Dr. Lind's Appendix.

cattle, being fed upon ſour draff, muſt yield aceſcent milk.

Salep, in a certain proportion, which I have not yet been able to aſcertain, would be a very uſeful and profitable addition to bread. I directed one ounce of the powder to be diſſolved in a quart of water, and the mucilage to be mixed with a ſufficient quantity of flour, ſalt, and yeaſt. The flour amounted to two pounds, the yeaſt to two ounces, and the ſalt to eighty grains. The loaf when baked was remarkably well fermented, and weighed three pounds two ounces. Another loaf, made with the ſame quantity of flour, &c. weighed two pounds and twelve ounces; from which it appears that the ſalep, though uſed in ſo ſmall a proportion, increaſed the gravity of the loaf ſix ounces, by abſorbing and retaining more water than the flour alone was capable of. Half a pound of flour and an ounce of ſalep were mixed together, and the water added according to the uſual method of preparing bread. The loaf when baked weighed thirteen ounces and a half; and would probably have been heavier, if the ſalep had been previouſly diſſolved in about a pint of water. But it ſhould be remarked, that the quantity of flour uſed in this trial was not ſufficient to conceal the peculiar taſte of the ſalep.

The reſtorative, mucilaginous, and demulcent qualities of the Orchis root render it of conſiderable uſe in various diſeaſes. In the ſea ſcurvy it powerfully obtunds the acrimony of the fluids, and at the ſame time is eaſily aſſimulated into a mild and nutritious chyle. In diarrhœas and the dyſentery it is highly ſerviceable, by ſheathing the internal coat of the inteſtines, by abating irritation, and gently correcting putrefaction. In the ſymptomatic fever, which ariſes from the abſorption of pus, from ulcers in the lungs, from wounds, or from amputation, ſalep uſed plentifully is an admirable demulcent, and well adapted to reſiſt that diſſolution of the craſis of the blood, which is ſo evident in theſe caſes. And by the ſame mucilaginous quality, it is equally efficacious in the ſtrangury and dyſury; eſpecially in the latter when ariſing from a venereal cauſe, becauſe the diſcharge of urine is then attended with the moſt exquiſite pain, from the ulcerations about the neck of the bladder, and through the courſe of the urethra. I have found it alſo an uſeful aliment for patients who labour under the ſtone or gravel [*].

From theſe obſervations, ſhort and imperfect as they are, I hope it will ſufficiently appear that the culture of the Orchis root is an object of conſiderable importance to the public, and highly worthy of encouragement from all the patrons of agriculture. That taſte for experiment, which characteriſes the preſent age, and which has ſo amazingly enlarged the boundaries of ſcience, now animates the RATIONAL FARMER, who fears not to deviate from the beaten tract whenever improvements are ſuggeſted,

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[*] The ancient chemiſts ſeem to have entertained a very high opinion of the virtues of the Orchis root, of which the following quotation from the SECRETA SECRETORUM of Raymund Lully, affords a diverting proof. The work is dated 1565.

SEXTA HERBA,
Satirion.

"Satirion herba eſt pluribus nota, hujus radicis collecta ad pondus lib. 4. die 20 menſis Januarij, contunde fortiter et maſſam contuſam pone in ollam de aurichalcum habente in coopercu-lo 20 foramina minuta ſicut athomi, & pone intus cù prædicta meſſa lactis vaccini calidi ſicut mulgetur de vacca ℔. 3. & mellis libram 1. vini aromatici ℔. 2. & repone per dies 20. ad ſolem & conferua & utere."

"Iſtius itaq; doſis ad pondus 3. 4. & hora diei decima exhibita mulieri poſt ipſius menſtrua eadem nocte còcipiet ſi vir cum ea agat."

geſted, or uſeful projects are pointed out to him. Much has been already done for the advancement of agriculture; but the earth ſtill teems with treaſures which remain to be explored. The bounties of nature are inexhauſtible, and will for ever employ the art, and reward the induſtry of man.

ESSAY VIII.

On the Preparation of Carrots for the Uſe of Seamen in long Voyages.

THE great utility of all kinds of vegetables in curing and preventing that ſpecies of the ſcurvy to which ſeamen are particularly liable, is ſo clearly aſcertained, that it will be unneceſſary to employ any time in the proof of it; I ſhall therefore proceed to deſcribe a remedy of the vegetable kingdom that probably may anſwer the happy purpoſes of preventing, mitigating, or curing the ſea ſcurvy, and all ſuch diſeaſes as derive their origin from the want of vegetable food.

The vegetable I mean to recommend is Carrots, and as it is impoſſible to preſerve them in their natural ſtate for any length of time, we muſt be content with an artificial preparation. The following is the method I have ſucceſsfully made uſe of.

Take any quantity of Carrots in the months of September or October. Let them be topped and tailed, and afterwards waſhed clean in warm water. Scrape them, and cut them into pieces about two inches in length, throwing away ſuch parts as are decayed. Put the whole into a large copper, with as much water as will preſerve the bottom from burning. Cover them up cloſe, and light a moderate fire underneath, ſo that the Carrots may be ſtewed and ſoftened in the ſteam. When they have become ſufficiently ſoft, let them be maſhed and pulped through a coarſe ſieve. Then take a quantity of loaf ſugar equal to the weight of the pulp, and, according to the rules of confectionary, reduce the whole over the fire to a proper conſiſtence, taking care to evaporate the ſuperfluous moiſture by continual ſtirring. When cold, put this marmalade into pots, covering it over with a paper moiſtened in brandy; and over that ſuch another covering as is generally recommended for conſerves.

This I conſider as the neateſt preparation of Carrots, and may be recommended for tarts, dumplins, &c. for the officers tables. Another preparation for the ſeamen may be made with coarſer ſugar; and the Carrots, inſtead of being pulped through a ſieve, may be maſhed by the circular ſtone employed in the cyder mills, and afterwards boiled up to a proper conſiſtence. And as this laſt preparation will be conſumed in large quantities, it may be put up into ſmall caſks.—The quantity intended for one day's conſumption, ſhould be taken out and mixed in an earthen or wooden veſſel, with as much of the ſtrong ſpirit of vitriol as will give it a grateful degree of acidity; after which it may be uſed in a variety of forms. A ſpoonful of this marmalade, put to a proper quantity of water, makes a cool and wholeſome drink in fevers, and all diſorders proceeding from putreſcency; and probably when given in this manner, with a little brandy, it may become a general preſervative againſt the ſcurvy. Seamen may alſo have it in the form of dumplins, in which ſhape a full meal of vegetable food may be afforded at a ſmall expence.

In order to be ſatisfied that this cheap and palatable antiſcorbutic will keep in a warm climate, I preſerved ſome pots of it, for twelve months, in a room heated with a conſtant fire, and had the pleaſure to obſerve that it kept extremely well. I ordered ſome of the pots to be acidulated, but the conſerve did not keep ſo well; ſo that it is the better way to uſe the acid occaſionally, as formerly directed.

A palatable meſs may be made as follows: Take Carrot-marmalade, one large ſpoonful; ſalop, in powder, one tea-ſpoonful. Acidulate with lemon-juice or ſpirit of vitriol; then add warm water, half a pint; wine, four ſpoonfuls; ſpices, a ſmall portion, if required. This mixture is highly antiputreſcent and nutritive.

The health of the Britiſh ſeamen is ſo eſſential to the welfare and intereſt of theſe kingdoms, that I flatter myſelf every attempt that has this great object in view, will meet with a favourable reception.

ESSAY IX.

On Bones uſed as a Manure.

DURING a long courſe of ſpeculative and practical Agriculture, in which, with critical exactneſs, I employed myſelf in making experiments upon almoſt every kind of manure, I was fortunate enough to diſcover that bones are ſuperior to all the manures made uſe of by the farmer.

Eight years ago I laid down to graſs a large piece of very indifferent limeſtone land with a crop of corn; and, in order that the graſs-ſeeds might have a ſtrong vegetation, I took care to ſee it well dreſſed. From this piece I ſelected three roods of equal quality with the reſt, and dreſſed them with bones broken very ſmall, at the rate of ſixty buſhels per acre. Upon the lands thus managed, the crop of corn was infinitely ſuperior to the reſt. The next year the graſs was alſo ſuperior, and has continued to preſerve the ſame ſuperiority ever ſince, inſomuch that in ſpring it is green three weeks before the reſt of the field.

This year I propoſe to plow up the field as the *Feſtuca Sylvatica (Prye Graſs)* has overpowered the graſs-ſeeds originally ſown. And here it will be proper to remark that, notwithſtanding this ſpecies of graſs is the natural produce of the ſoil, the three roods on which the bones were laid have hardly any of it, but on the contrary have all along produced the fineſt graſſes.

Laſt year I dreſſed two acres with bones in two different fields prepared for turnips, ſixty buſhels to the acre, and had the pleaſure to find the turnips greatly ſuperior to the others managed in the common way. I have no doubt but theſe two acres will preſerve their ſuperiority for many years to come, if I may be allowed to prognoſticate from former experiments moſt attentively conducted.

I alſo dreſſed an acre of graſs ground with bones laſt October (1774) and rolled them in. The ſucceeding crop of hay was an exceeding good one. However, I have found from repeated experience that, upon graſs ground, this kind of manure exerts itſelf more powerfully the ſecond year than the firſt.

It muſt be obvious to every perſon, that the bones ſhould be well broken before they can be equally ſpread upon the land. No pieces ſhould exceed the ſize of marbles. To perform this neceſſary operation, I would recommend the bones to be ſufficiently bruiſed by putting them under a circular ſtone, which being moved round upon its edge by means of a horſe, in the manner that tanners grind their bark, will very expeditiouſly effect the purpoſe. At Sheffield it is now become a trade to grind bones for the uſe of the farmer. Some people break them ſmall with hammers upon a piece of iron, but that method is inferior to grinding. To aſcertain the comparative merit of ground and unground bones, I laſt year dreſſed two acres of turnips with large bones, in the ſame field where the ground ones were uſed; the reſult of this experiment was, that the unground materials did not perform the leaſt ſervice; while thoſe parts of the field on which the ground bones were laid were greatly benefitted

I find that bones of all kinds will anſwer the purpoſes of a rich dreſſing, but thoſe of fat cattle I apprehend are the beſt. The London bones, as I am informed, undergo the action of boiling-water, for which reaſon they muſt be much inferior to ſuch as retain their oily parts; and this is another of the many proofs given in theſe eſſays that oil is the *food* of plants. The farmers in this neighbourhood are become ſo fond of this kind of manure, that the price is now advanced to one ſhilling and fourpence per buſhel, and even at that price they ſend ſixteen miles for it.

I have found it a judicious practice to mix aſhes with the bones; and this winter I have ſix acres of meadow land dreſſed with that compoſt. A cart load of aſhes may be put to thirty or forty buſhels of bones, and when they have heated for twenty-four hours (which may be known by the ſmoaking of the heap) let the whole be turned. After laying ten days longer this moſt excellent dreſſing will be fit for uſe.

ESSAY X.

On the Effects of fixed Air on the Colours and Vegetation of Plants.

THE influence of fixed Air on vegetation is a new, curious, and very intereſting object of inquiry. I was led into it by a train of experiments, which the following paſſage, in Dr. Prieſtley's Obſervations on Various Kinds of Air, ſuggeſted to me. "A red Roſe, freſh gathered, loſt its redneſs, and became of a purple colour, after being held over fermenting liquor about twenty-four hours; but the tips of each leaf were much more affected than the reſt of it. Another red Roſe turned perfectly white in this ſituation; but various other flowers, of different colours, were very little affected. Theſe experiments were not repeated, as I wiſh they might be done, in pure fixed Air, extracted from chalk by means of oil of vitriol."

March 16th, 1775. I expoſed a Tulip, forty-eight hours, to a ſtream of fixed Air, ſeparated from chalk by means of oil of vitriol. The colours and odour were preſerved unchanged; the leaves were curled at the edges, but remained firm and undecayed. Another Tulip, gathered at the ſame time, from the ſame root, and ſimilar in colour, ſoon became faded, flaccid, and loſt its odour in the common atmoſphere.

The ſame experiment was made with a purple Crocus; with a white and yellow Jonquil; with the Hepatica; with a Polyanthos of a purple hue; and with a Stock July-flower. They were all perfectly preſerved in the veſſel of fixed Air; whilſt ſpecimens of the ſame flowers ſpeedily loſt their bloom, and turned ſoft and ſhrivelled in the open air.

The Italian Narciſſus, a delicate flower, which grew in a hot-houſe, retained its colours forty-eight hours in the fixed Air; but the petals (or leaves of the flower cup) were very much contracted.

A pale red Roſe, taken from a hot-houſe, was expoſed twenty-four hours to a ſtream of fixed Air, without ſuffering any change of colour.

lour. It was carefully compared with another Roſe collected from the ſame tree *.

The reſult of this experiment differs from that related by Dr. Prieſtley. But it is probable that the fixed Air, ſeparated from fermenting liquors, is leſs pure and unmixed than that obtained from chalk by the addition of oil of vitriol, and that its effects may be varied by the adventitious matters with which it is combined.

The preſervation of flowers by mephitic Air was an event which I little expected at the commencement of theſe trials. And as an active mind is ſeldom ſatisfied with the bare obſervance of effects, without inquiring into the cauſes which produce them, I was naturally led into a train of reaſoning on this curious ſubject. It was well known to me, that vegetables, before the putrid fermentation begins, emit a very large proportion of fixed Air †.

But

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* Mr. Henry expoſed ſeveral red Roſes, in the ſummer of 1774, to a ſtream of pure fixed Air, and did not find any change produced in their colour. See his excellent tranſlation of Lavoiſier's Eſſays Phyſical and Chemical, which he has enriched with various uſeful notes, page 130.

† See Prieſtley's Obſervations, vol. I.

But this ſeparation can only take place by the mediation of ſome body, which is capable of carrying off what is diſcharged. A wet ſpunge will never become dry in an atmoſphere ſaturated with moiſture, and red hot wood ceaſes to burn in inflammable Air, which is already loaded with phlogiſton. I was induced, therefore, to ſuppoſe that the flight of mephitic Air from flowers, which ſeems to conſtitute the firſt ſtage of their decay, is prevented or conſiderably retarded by ſurrounding them with the ſame ſpecies of Air, and by excluding from them the common atmoſphere, its proper vehicle *.

But the proſecution of my experiments diſcovered to me, that fixed Air not only retards the decay, but actually continues the vegetation of plants, and affords them a *pabulum*, which is adequate to the ſupport of life and vigour in them for a conſiderable length of time.

Tueſday. A ſprig of Mint was ſuſpended, with the root upwards, in a veſſel of fixed Air.

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* See this ſubject, ſo far as it relates to putrefaction, farther illuſtrated in the ſecond volume of Percival's Eſſays, p. 84.

The ſucceeding day it was as freſh and verdant as when firſt gathered. Another ſprig, collected at the ſame time and from the ſame bed, which lay upon my table, was quite withered. Friday, the fourth day, a curve was formed in the middle of the ſtalk, and the top of the ſprig had riſen about an inch perpendicularly towards the mouth of the veſſel. Saturday, the Mint continued to grow and to aſcend, looking vigorous and freſh: the root, which was very ſmall, appeared quite dry, ſo that the nouriſhment probably was imbibed by the leaves. Tueſday, having been abſent two days, the plant was not ſupplied with freſh ſtreams of Air: it was ſtill in vigorous vegetation. Friday, the eleventh day of the experiment, the plant was taken out. It was perfectly freſh, but whilſt it lay on my ſtudy table the leaves grew ſoft and flaccid, and in leſs than ſix hours it ſeemed to be withered. The mercury in Fahrenheit's thermometer, during the courſe of this experiment, ſtood from 60 to 69 degrees in the ſhade and open air, at two o'clock in the afternoon.

March 23d. Two ſprigs of Mint with their roots, freſh gathered from the ſame bed, and nearly alike in ſize, were each put into an half ounce phial, filled with rain-water. One of them was ſuſpended four days and an half in a veſſel of fixed Air, and frequently ſupplied from chalk and oil of vitriol with freſh ſtreams of it. The other was placed near it, in the common atmoſphere of my ſtudy; and a few ſprigs of Mint, with their roots, were at the ſame time laid upon the table. The latter withered in about twelve hours, and in twenty-four hours were dry and quite ſhrivelled. The ſprig in the fixed Air flouriſhed greatly; ſhot out freſh leaves from the part immediately above the neck of the phial; expanded its leaves; looked verdant; and when taken out of the fixed Air, had gained in length more than half an inch. The ſprig in the common atmoſphere looked ſickly; the leaves were contracted, had a brown and curled appearance, and ſeveral of them were become dead and rotten.

March 28th. The flouriſhing ſprig of Mint, which had been ſuſpended in the fixed Air, was now placed in the common atmoſphere of my ſtudy; and the other, which was ſo much faded, was put into the veſſel of fixed Air. In two hours time the leaves of the former began to droop and grow flaccid, like a plant taken from a hot-bed, and in twenty-four hours they were in a withered ſtate. The latter ſprig was much revived by the fixed Air, but did not vegetate in nearly ſo vigorous a manner as the firſt had done. It was kept four days in the veſſel, and daily furniſhed with freſh ſupplies of fixed Air.

April 1ſt. The water, in which the ſprig of Mint grew that had been ſuſpended in fixed Air, became impregnated with this active principle, as appeared from its acidulous taſte, and from its producing an inſtant precipitation when mixed with lime-water. This incited me to try how a plant would vegetate in mephitic water, with its leaves and branches expoſed to the common atmoſphere. A ſprig of Mint was therefore put into a phial, containing about ſix ounces of it. The ſtalk paſſed thro' a perpendicular groove, cut in a cork, which ſtopped the mouth of the bottle, to prevent the eſcape of the fixed Air. In two days the leaves of the Mint became curled at the edges, and the plant ſeemed to be in a leſs thriving ſtate than another ſprig of Mint placed in rain-water, which ſerved as a ſtandard. Suſpecting that the ſtalk of the Mint was compreſſed and injured by the cork, I renewed the experiment,

ment, uſing freſh ſprigs of Mint and other portions of water, and leaving the mouth of the phial, which held the mephitic water, open to the external Air. The vegetation of the plant, in this water, was now very vigorous, and the growth of it, in ſix days, conſiderably exceeded that of the ſtandard.

April 8th. The experiment of March 23d was repeated, and the ſprig of Mint, placed in a phial, containing half an ounce of rain-water, and ſuſpended in a veſſel conſtantly ſupplied with freſh ſtreams of fixed Air, grew above an inch within the ſpace of ſix days. Another ſprig, in half an ounce of ſimple rain-water, was in a much leſs healthy ſtate, and had ſcarcely acquired any perceptible increaſe in that time.

April 14th. This experiment was repeated with a ſprig of Balm, which flouriſhed and grew faſt in the fixed Air.

It has been ſhewn that a plant grows faſter in mephitic than in ſimple unimpregnated water. The following experiments ſeem to evince, that the fixed Air is abſorbed by the roots of the vegetable, and that it affords them real nouriſhment.

April 18th. A ſprig of Mint, with a ſhort root, was put into a ſix-ounce phial, full of rain-water, ſtrongly impregnated with fixed Air. Another phial of the like ſize was filled with the ſame mephitic-water, and placed without a cork, contiguous to the former, upon a ſhelf in my ſtudy. At the end of four days they were carefully examined: the ſprig of Mint was in a very flouriſhing ſtate, and the water in which it grew had loſt its acidulous taſte, yet it produced a precipitation when mixed with lime-water. But the ſtandard of mephitic-water ſtill retained a conſiderable degree of pungency, and when poured into lime-water, rendered it quite milky.

An Auricula, fully blown, and juſt gathered from my garden at Hart-Hill, was ſuſpended by a ſtring in the veſſel of fixed Air, and frequently ſupplied with freſh ſtreams of it. The bloom of this delicate flower continued perfectly unimpaired during eight days, when it was withdrawn, as the proſecution of the experiment interfered with another which I had in view. The Auricula, when taken out of the fixed Air, withered in a few hours.

May 2d. A Lilac, before the flower was blown, was put into the veſſel of fixed Air, and occaſionally, but not frequently, ſupplied with freſh ſtreams of it. It weighed, at the commencement of this experiment, two ſcruples thirteen grains and an half; and when taken out, at the expiration of ſeven days, only thirty-three grains, having loſt one ſcruple and half a grain of its weight. The flower was a little withered, as much, I conjectured, as it would have been by lying in the open air about ſix hours. The ſtalk was dry. This flower was without any green leaves; and it is not improbable that the abſorbent veſſels are confined to theſe leaves *.

A Tulip, about half blown, was put into the veſſel with the Lilac. It ſeemed not to flouriſh, but opened ſo much in the veſſel, that, at the end of ſeven days, I found a difficulty in taking it out of the aperture, thro' which, at

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* See Grew's Anatomy of Plants. Hales's Statical Eſſays. Hunter's Georgical Eſſays.

at firſt, it had paſſed very readily. The Tulip had no leaves: its colour remained unchanged.

May 10th. A branch of Lilac, which weighed eighty-ſix grains and an half, was put into the veſſel. Some of the flowers were blown, but moſt of them remained in a cloſed ſtate. I plucked off four green leaves before the branch was expoſed to the fixed Air, to ſee whether it would grow and flouriſh by the abſorption of the flowers and ſtalk alone. It ſhould be remarked that the ſtalk of the Lilac is woody and not very ſucculent.

May 18th. The Air had not been renewed during forty-eight hours, owing to my abſence from Mancheſter. Several of the flower cups of the Lilac were more open than at firſt, but the flowers were ſomewhat withered, probably as much as they would have been by lying eight or ten hours in the open Air. The whole branch had loſt eighteen grains of its weight.

A purple Flower, unblown, was ſuſpended in the veſſel with the Lilac. It weighed two ſcruples and ten grains, and was without leaves. The ſtalk was ſucculent.

May 18th. The Air had not been renewed during forty-eight hours, yet the flower was perfectly freſh, and its purple colour remained unchanged. Several of the flower cups were opened and the ſeeds diſplayed. It had loſt ſix grains of its weight.

Having thus opened a path into a new and fertile region of ſcience, I ſhall diſcontinue my reſearches for a while, with a reſolution however to reſume them in the ſpring of the ſucceeding year. In the mean time I ſhall think myſelf happy if I can prevail upon my philoſophical friends to engage in the ſame purſuit, by offering them, as a clue, theſe few experiments, together with the following obſervations and conjectures, which have occurred to my mind during the proſecution of them.

SPECULATIONS.

1. The Floriſt, who is anxious to obtain a prize at ſome of the great meetings held for the encouragement of Horticulture, may perhaps avail himſelf of the powers of fixed Air, and either quicken the growth of his favourite flower, if yet immature, or preſerve it in all its beauty till the expected day of deciſion.

But it will be neceſſary to inform him that the mephitic Air ſhould be frequently renewed, or it will be corrupted by the perſpiration of the vegetable. For plants, like animals, form an atmoſphere around them, which proves unfavourable to their health, if not removed. An Auricula was ſuffered to remain in the ſame fixed Air many days. Its colours ſeemed not much changed, but a mouldineſs was viſible in the flower cups. The leaves were ſoft and flaccid, and the fine bloom of the flower was loſt. Theſe effects I aſcribed to the cauſe above mentioned. But my gardener has ſince ſuggeſted a doubt to me, by informing me that Auriculas grow mouldy when the ſeed is completed. And it is poſſible that, in this experiment, the flower had finiſhed its proper office, and was gone into a natural, not premature decay.

2. Perhaps valuable ſeeds, collected in diſtant climates, may be preſerved by fixed Air, and tranſported to other regions in the moſt perfect ſtate of vegetation.

3. Is there any analogy between the torpid ſtate of animals, during winter, and the preſervation of flowers, ſtripped of their leaves,

by means of fixed Air? The vital principle ſeems to be preſerved in both, and the juices of each are ſlowly conſumed in the ſupport of it.

4. The *Gas* of fermenting liquors appears to differ in ſome reſpects from pure fixed Air. It affects the head and ſtomach more powerfully, changes the colours of flowers, and is preſently fatal to ſprigs of Mint which are expoſed to it.

5. A plant in diſtilled water, Dr. Woodward obſerves, will not grow ſo faſt as in water that is not diſtilled. And if the water be diſtilled three or four times, the plant will ſcarcely vegetate at all. Diſtilled water is deprived of its fixed Air, which is probably one of the conſtituent parts of this Element, eſſential to the nouriſhment of plants.

6. Land well drained, cultivated, and manured, is conſtantly in a ſtate of inteſtine fermentation *. The exhalations which ariſe from

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* Culture has a remarkable effect on climate. Draining land leſſens evaporation, and conſequently diminiſhes moiſture and cold. *Cold* and *barren* are terms always aſſociated together, when applied to ſoils. The felling of trees, clearing away underwood,

it may perhaps, in part, conſiſt of fixed Air; and this principle may be found to prove a very powerful agent in the proceſs of vegetation. Froſt meliorates ſoil chiefly by retaining theſe exhalations; the loſs of which impoveriſh and exhauſt it. Snow alſo, when it lies long on the ground, prevents the diſſipation of them, and thus affords time and opportunity for their abſorption by the roots and leaves of plants.

7. Dr. Prieſtley has diſcovered that vegetables thrive admirably in putrid Air, and alſo in that which has been corrupted by the breath of animals, and by the burning of candles; and that they reſtore ſuch Air from a highly noxious,

derwood, and cropping of hedges, occaſions a more free circulation of air, and a drier climate. The perſpiration of trees and exhalations from wet land render the air colder, and cold air is leſs capable of diſſolving moiſture. When warmer air, therefore, which is ſaturated with aqueous vapours, paſſes over any colder region, the water will be precipitated in drops of rain. Hence uncultivated countries, *cæteris paribus*, are moſt rainy.

These remarks are not entirely foreign to the ſubject of this eſſay. And I have introduced them here to exhibit the importance of agriculture, in a point of view, in which it is ſeldom beheld, either by the ſpeculative or practical farmer, who are little aware that they have an intereſt in every improvement made by their neighbours.

noxious, to a ſalutary and reſpirable ſtate. This effect he ſuppoſes to be produced by their inhaling thoſe effluvia, which are ſo fatal to animal life, and not by any addition to the atmoſphere which ſurrounds them. From the foregoing experiments, we have reaſon to preſume, that this wonderful and moſt uſeful power of plants is extended to another ſpecies of noxious Air; and it will be the firſt object of my future trials to aſcertain this curious and important truth. Such diſcoveries heighten our admiration of the wiſdom and goodneſs of the Deity, by affording us freſh proofs that nothing is created in vain. "From the Oak of the foreſt to the Graſs of the field, every individual plant is ſerviceable to mankind; if not always diſtinguiſhed by ſome private virtue, yet making a part of the whole which cleanſes and purifies our atmoſphere. In this the fragrant Roſe and deadly Nightſhade co-operate: nor is the Herbage, nor the Woods that flouriſh in the moſt remote and unpeopled regions unprofitable to us, nor we to them, conſidering how conſtantly the winds convey to them our vitiated Air, for our relief and for their nouriſhment." *

8. As

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* See a Diſcourſe on different kinds of Air, delivered at the anni-

8. As fixed Air is ſo favourable to the growth of vegetables, perhaps it may equally contribute to the nouriſhment and ſupport of animals. It is ſeparated from our food during the proceſs of digeſtion, and it may only be injurious to us when too copious, as exceſs in the quantity of water proves hurtful to the roots of plants.

I have communicated to many of my friends an account of the above experiments on vegetation, as influenced by fixed Air; and I flatter myſelf that the ſubject will engage the attention, and excite the trials, of thoſe who have a taſte for purſuits of this nature. Mr. Bew, who was a witneſs to the flouriſhing ſtate of my ſprigs of Mint growing in mephitic water, has lately tried a ſimilar experiment with two Hyacinths; and I ſhall lay before the reader his account of the ſucceſs of it.

" December 2d, 1775. Two Hyacinth " bulbs, each weighing four drachms and a " few grains, were placed in glaſſes made for " the purpoſe of vegetating bulbous roots.

" One

anniverſary meeting of the Royal Society, November 30th, 1773, by Sir John Pringle, Baronet, F. R. S.

" One glaſs was ſupplied with ſeven ounces " and a half of pump-water, impregnated with " fixed Air; the other with the ſame quantity " of rain-water.

" Neither of the plants had made much " progreſs in vegetation. Some white fibrous " roots were ſhooting from the plant ſupplied " with rain water, but none from that which " had the water with fixed Air.

" December 17th. Several beautiful white " fibres were diſcovered ſhooting from the root " ſupplied with fixed Air, and both plants " were beginning to vegetate.

" The bulb ſupplied with rain water ſeemed " at firſt to make the greater progreſs in vegetation. The fibrous roots of the other " were, however, much ſtronger, whiter, and " more tranſparent.

" They were conſtantly ſupplied with their " reſpective kinds of water; and at intervals, " when I concluded that the factitious air was " exhauſted by the plant, the whole was poured off, and each glaſs filled at the ſame time " with the ſame quantity of its proper water.

" January 1ſt, 1776. The plant immerſed " in the water impregnated with fixed Air ſur- " paſſed the other in the ſtrength and colour of " its leaves, which were of a lively green, and " the roots of a moſt beautiful tranſparent " white. The other plant, though apparently " healthy, had very few roots.

" January 16th. Both plants continued to " vegetate, but the one ſupplied with fixed " Air much more than the other, and it ſeem- " ed equally forward with ſome other bulbs " which had been placed in common rain wa- " ter near a month before. An accident, how- " ever, happened at this time, which, I appre- " hended, would have put an end to my expe- " riment: My ſervant, in letting down a large " curtain before the window where theſe glaſſes " were placed, overturned that which contain- " ed the water with fixed Air. The night was " rather ſevere, and the plant lay ten or eleven " hours out of water. I replaced it in another " glaſs with the mephitic water, and continued " to ſupply them as uſual.

" January 21ſt. I was much ſurprized to " find the plant had recovered its former vi- " gour, and was advancing a ſtem with buds

" for flowering, which the other plant ſhewed " no ſigns of.

" The weather at this time became ſo cold, " that I thought it neceſſary to remove all the " plants out of the window of my parlour to " a warmer part of the room, that the progreſs " of their vegetation might not be retarded.

" February 6th. The glaſſes were replaced " in the window, and each ſeemed in a very " healthy ſtate. That ſupplied with mephitic " water viſibly increaſed every day.

" The plant in the rain water had advanced " a ſtem with buds, but not more than half " the ſize of the other.

" February 27th. The Hyacinth which had " been ſupplied with water impregnated with " fixed Air was in full blow, appeared remarkably " ſtrong, and diffuſed the delicate fragrance " peculiar to the flower. It meaſured " from the bulb full ſixteen inches. I withdrew " it gently from the water, and found it " weighed two ounces, two drachms, and five " grains.

" The other Hyacinth was juſt beginning to
" expand its flower. It meaſured no more
" than ten inches from the bulb; and, though
" freſh and vigorous, weighed only one ounce,
" one drachm, and ſix grains."

This experiment of Mr. Bew would have been more deciſive if he had employed rain water impregnated with fixed Air, and not pump water; but it coincides with the trials which I have related, and ſufficiently evinces the powerful influence of this principle on vegetation.

It is a common cuſtom with gardeners to expoſe pump water to the ſun and air to ſoften it, many hours before they uſe it for the purpoſe of ſprinkling their plants and flowers. This ſhould ſeem to be an injudicious practice, if the hardneſs of the water ariſe, as it often does, from the fixed Air which it contains; for it will thus be deprived of that conſtituent part which has been ſhewn to be ſo friendly to vegetable life. Mephitic air is found in many common ſprings; and ſuch ſhould always be ſelected for the uſes of gardening and agriculture. In green-houſes, water artificially impregnated might be employed without any great trouble or expence.

N. B. It may be proper to inform the reader, who would chooſe to repeat my experiments, that they were generally made with the apparatus for impregnating water with fixed Air, invented by Dr. Nooth, and ſold by Mr. Parker, glaſs-man, in Fleet-ſtreet, London.

ESSAY XI.

On the Action of different Manures.

1. I Apprehend that oily ſubſtances cannot produce any conſiderable effect on land, unleſs they be previouſly combined with mucilages, or converted into ſoap by means of quick-lime or fixed alkalis. In this ſtate they meliorate the ſoil in ſeveral ways, viz. by affording a laſting *pabulum* for plants; by fitting it to receive, and preventing the too ſpeedy evaporation of the dews and rains; and by preſenting the food of vegetables in a due proportion to the abſorbent veſſels of their roots.

2. Saline ſubſtances, as they are ſoluble in water, and capable of admiſſion into the vaſcular tubes of plants, act more immediately on the earth. Whether they afford any real nutriment to vegetables, or whether their operation depends upon a ſtimulating power, by which they quicken vegetation, I am at a loſs to determine; for that plants are endued with irritability is evident from various facts. The ſenſitive tribe of vegetables afford us ocular demonſtration of it; and electricity is well known to accelerate the growth of plants by promoting the aſcent of their juices.

3. Common ſalt is univerſally eſteemed an excellent manure; but I think it would be ſtill more powerful if a proper quantity of Epſom ſalt were added to it. By this combination it would more exactly reſemble ſea-water, which amazingly fertilizes the marſhes over which it flows. The graſs of ſuch marſhes is purgative to horſes and to cattle, which affords a preſumptive proof that ſea-ſalt, mixed with the bittern, may be received into the veſſels of plants in a much larger proportion than when purified and refined. The combination here recommended will act as a powerful ſeptic, when mixed with the corrupted vegetables and

other putrefying ſubſtances on the ſurface of the earth; and by this fermentation will improve the ſoil.

4. Quick-lime is not claſſed by the modern chemiſts amongſt the ſalts, though it has ſome properties in common with them. It may act as a manure by combining with and dividing the particles of clay, and thus forming a ſpecies of marl; by uniting with the oily ſubſtances contained in the ſoil, and rendering them ſoluble in water; and by abſorbing the dews and rains, and preventing them from ſinking too ſpeedily into the earth, by which the food of plants is waſhed from their radical fibres.

5. Lime and the fixed alkalis are more powerful agents than neutral ſalts in preparing the food of vegetables, by their operation on the oils and mucilages which exiſt in the ſoil, and which have been ſupplied by manures, or derived from the atmoſphere.

ESSAY XII.

On the Action of Lime and Marl as Manures; and the making of artificial Marl for the Purpoſes of Agriculture.

THE principles on which different manures produce advantages, in the ſoils to which they are applied, ſeem to claim a more particular inveſtigation than the ſubject has hitherto received. A very ingenious writer * has indeed made great advances in theſe intereſting reſearches; yet it is apprehended much ſtill remains undone, and the inquiry is truly worthy of all the elucidation which can poſſibly be procured.

Manures have been ſuppoſed to act, either by adding nouriſhment to the ſoil; by preparing the nouriſhment, which it already contains, for the digeſtion of the plants; by enlarging the vegetable paſture of the ſoil; or by attracting the food of plants in greater plenty from the air †.

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* Home's Principles of Agriculture and Vegetation; a work well deſerving the attention of every philoſophical farmer.

† Georgical Eſſays, Vol. III. 12mo. edit.

Under the ſecond of theſe heads are placed thoſe manures, which as they are not ſuppoſed themſelves to afford nutriment, are ſuſpected of exhauſting the ſoil, by too haſtily reducing the putreſcible matter into mucilage; and thus, though greater crops be at firſt produced, leaving the land in a weaker ſtate than it was in before the reception of the aid afforded by theſe tranſient auxiliaries.

Lime is, in general, claſſed among theſe forcing manures, perhaps with ſome degree of injuſtice. It is probable that lime may afford food to plants, by the ſalts it may form in conjunction with the acids with which it may meet. Its effects will doubtleſs be more or leſs durable, in proportion to the nature of the land on which it is laid*. On ſtiff clay they will be much more permanent, than on light ſand or ſoil. Something may likewiſe depend on the ſtate in which it is uſed.

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* For a particular account of the effect of lime on different ſoils, ſee Mr. Young's Tour thro' the Eaſt of England, Vol. IV. p. 394, &c. See alſo Home's Principles of Agriculture, p. 58.

Lime is calcareous earth deprived of its fixed Air * and water, but which has acquired in its calcination a conſiderable proportion of fire, as is apparent from the great heat and even ignition attending the ſlaking of lime with water and its ſolution in acids †.

How far this laſt principle may be advantageous to lime as a manure, is well deſerving of the inquiry of the practical farmer; whether, when applied to dry, light ſoils, it may not be prejudicial, by increaſing the property of calcareous earth to attract to itſelf and retain the moiſture of the ſoil, and by even *evaporating* too much of its water, till the extinction be completed. The evaporation of water, in the ſlaking of lime, is ſurpriſingly great; beſides which, the lime obſtinately retains a conſiderable portion, viz. one-fourth or one-fifth of its weight, of the water employed in the proceſs, though dried in a conſiderable degree of heat. It

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[*] Fixed Air enters into the compoſition of many bodies in which it remains in an unelaſtic ſtate. It is the vapour which eſcapes from fermenting ſubſtances, and is let looſe from alkaline ſalts or calcareous earth by the addition of acids, occaſioning that briſk motion in them which is called effervescence. It may alſo be diſcharged from theſe bodies by the action of fire.

[†] Vide Opuſcules Phyſiques et Chymiques, par M. Lavoiſier, Tome premier, p. 214; or Henry's Tranſlation of the ſame book, p. 252.

It may perhaps alſo prove injurious, by too quickly rendering the oily parts of the ſoil miſcible with water, and thereby expending them too faſt.

On the other hand, the fiery particles contained in quick-lime may be of ſingular ſervice in cold wet land, by promoting the diſſipation of part of the water, by afterwards abſorbing and condenſing other parts of it, and by more forcibly decompounding the aluminous and metallic ſalts which are often contained in ſuch grounds. It may alſo be uſeful in deſtroying ruſhes and other weeds, and by burning the ſmaller fibres of the graſs or corn roots, may make the plants more ſtrong and healthy.

It may admit of ſome doubt, however, whether calcareous earth, in its reduction to the ſtate of quick-lime, be not deprived of another principle which may have great uſe in vegetation. Some manures, as has been before obſerved, improve land by enlarging the vegetable paſture, viz. by breaking down and attenuating the ſoil, and thus giving room for the roots to ſpread out in ſearch of nouriſhment, and for the nutritious juices to percolate more freely. This property in manures depends on their diſpoſition

tion to ferment; and hence it is that dung ſhould always be laid on the land before the proceſs of putrefaction have proceeded too far. This is contrary to the practice of that excellent farmer Mr. Bakewell, and I ſhould therefore have been very diffident in embracing an opinion oppoſite to his, if I had not found it ſupported by many writers on agriculture; Mr. Young in particular blames Mr. Bakewell's manner, in ſuffering his dung to loſe all its moiſture, and the body of it to become powder like ſnuff, before he applies it. Though he acknowledges it to be very ſtrong, yet the diminution in quantity, ſays he, will make it nearly reſemble a rich top-dreſſing of ſoot, which has a moderate effect for only one crop †. But is there not reaſon to ſuſpect that the whole advantage ariſing from fermentation in manures, is not due to the mere mechanical effect produced by the inteſtine motion, in deſtroying the coheſion of the earthy particles? Is there not ſomething diſcharged during this proceſs which may be abſorbed by the roots of the plants, and afford them nutriment and ſupport? It is well known that both in the vinous and putrefactive fermentation, much fixed Air is diſengaged, and it is certain alſo that this kind of air is contained in conſiderable quantity in moſt vegetables.

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† Farmer's Tour thro' the Eaſt of England, Vol. IV. p. 449.

But the ſubſequent facts ſeem to place the doctrine which has been here advanced on a more firm foundation than that of conjecture. Dr. Percival made a number of very intereſting and entertaining experiments, the laſt ſpring, on the influence of fixed Air on vegetation; and his trials ſeem to evince that it affords actual nouriſhment to plants, and continues life in them, a conſiderable length of time, without any other ſupport. The following experiment he has ſelected, at my deſire, from many others which furniſh a ſimilar concluſion.

" Tueſday April 18th, 1775; A ſprig of
" mint was ſuſpended, with the root upwards,
" in a veſſel of fixed Air*. The ſucceeding day
" it was as freſh and verdant as when firſt ga-
" thered. Another ſprig collected at the ſame
" time and from the ſame bed, which lay upon
" my table, was quite withered. Friday the
" fourth day, a curve was formed in the middle
" of the ſtalk, and the top of the ſprig had riſen
about

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* As this experiment was made in Dr. Nooth's machine, there muſt neceſſarily have been a quantity of common air mixed with the ſixed Air. Plants *confined* in veſſels of pure ſixed Air, die.

" about an inch perpendicularly towards the
" mouth of the veſſel. Saturday, the mint con-
" tinued to grow and to aſcend, looked vigo-
" rous and freſh: The root which was very
" ſmall appeared quite dry, ſo that the nouriſh-
" ment, probably, was imbibed by the leaves.
" Tueſday, having been abſent two days, the
" plant was not ſupplied with freſh ſtreams of
" air: It was ſtill in vigorous vegetation. Fri-
" day the eleventh day of the experiment, the
" plant was taken out. It was perfectly freſh,
" but whilſt it lay on my ſtudy table the leaves
" grew ſoft and flaccid, and in leſs than ſix
" hours it ſeemed to be withered. The mercu-
" ry in Fahrenheit's thermometer, during the
" courſe of this experiment, ſtood from 60 to
" 69 degrees in the ſhade and open air, at two
" o'clock in the afternoon."

It alſo appears from Dr. Hales's experiments, that air enters in conſiderable quantity into plants, not only with the principal fund of nouriſhment by the roots, but alſo through the trunks and leaves, and is likewiſe mixed with the earth both in an elaſtic and unelaſtic ſtate.

The analogy between animal and vegetable nutrition likewiſe tends to confirm this theory. A great quantity of this elaſtic fluid is diſengaged from the aliment in the ſtomach and bowels, during the progreſs of digeſtion, and though, when from a weakneſs of theſe organs, it is accumulated in too great quantity, it may degenerate into diſeaſe, yet there is but little doubt of its great utility in the animal œconomy, in giving tone and vigour to the fibres, and checking the tendency to putrefaction inherent in all animal bodies: nay, it has even been ſuppoſed, by ſome philoſophers, to be the bond of union, the cement by which the elementary particles of bodies are combined.

Now calcareous earth or lime-ſtone, before calcination, or when it has been expoſed to the open air for ſeveral months after that operation, contains this fixed air and water to the amount nearly of one half of its weight *: When laid on land, in this ſtate, it gradually attracts the acid contained in the earth as well as that of the air; in uniting with it an effervescence is produced, which will be in proportion to the quantity and ſtrength

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* It appears from the ingenious Mr. Lavoiſier's experiments, that one hundred pounds weight of chalk contains about thirty-one pounds fifteen ounces of fixed air, fifteen pounds ſeven ounces of water, and fifty-two pounds ten ounces of alkaline earth. *Opuſcules Phyſiques et Chymiques, par M. Lavoiſier, Tome premier, p.* 213.—Henry's Tranſlation, p. 251.

ſtrength of the acid either ſudden and violent, or moderate and long continued. The latter will generally be the caſe, and is more deſirable, as, by the gentle but conſtant agitation, the earth will be kept continually looſe, and from the ſlow detachment of the fixed Air, the roots of the plants will more effectually abſorb it, without an uſeleſs expence of it being ſuffered *.

Marl is generally allowed to be, when properly applied, a very laſting improvement. Mr. Young mentions inſtances of its continuance for forty and fifty, and, of one ſpecies, even for an hundred years. The nature of this manure has of late been clearly aſcertained by an ingenious phyſician, who has favoured the public with the reſult of his experiments †. By theſe we are not only made acquainted with the component parts of marl, but the farmer is alſo taught to determine the different proportions of theſe parts in different marls; a knowledge of great importance, as he will hereby be enabled to judge with preciſion of the quantity to be applied, according to the contents of the marl, and the nature of the land intended to be improved.

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* On this account, when applied to corn land, this manure ſhould not lie too long expoſed to the air before it be ploughed in.

† Georgical Eſſays, Vol. III. p. 25. 12mo. edit.

We learn from theſe experiments that marl conſiſts of calcareous earth, clay and ſand, mixed in various proportions in different parcels of that manure. The firſt of theſe ſubſtances is involved, as it were, in coatings of the clay. May not this covering, by defending it from the ſudden action of the acids contained in the ground, and preventing the too rapid effects of the calcareous earth itſelf on the putreſcent and oily matter of the ſoil, account for the greater permanency of this compound than of calcareous earth alone, either in a cauſtic or mild ſtate? For though it appears from Dr. Ainſlie's experiments, contrary to the impudent aſſertions of an advertiſing quack in agriculture, that marl does not form any ſalt with the acid of the air, even from long expoſure to the atmoſphere, yet it is probable that when powdered and mixed with the ſoil, it will not only unite with the acid which it may find there, but alſo attract it from the circumambient air.

But a more important benefit ariſing from Dr. Ainſlie's analyſis has perhaps been hitherto overlooked; I mean the artificial compoſition of marl for the purpoſes of agriculture; and I truſt that the ſcarcity of this ſubſtance in ſome countries will be a ſufficient apology for my ſoliciting the attention of the public to the ſubject. Mr. Young relates, "that the "farmers in Fleg hundred bring it from Norwich to Yarmouth by water, and then from "four to eight miles by land, at the expence of "ſeven ſhillings and four-pence per cart load; "and that in the neigbourhood of Colcheſter "they give, after it has been brought from "Kent by ſhipping, from ſeven ſhillings to "nine ſhillings a load for it, and carry it even "ten miles." *

Artificial compoſts, of different kinds, have long been uſed in agriculture, but no attempt has been made to introduce the uſe of artificial marl. Though the ingenious experimentaliſt above-mentioned, has demonſtrated of what materials the conſtituent parts of marl conſiſt, though he even proceeded to make factitious marl for the purpoſes of chemical experiments, yet the idea does not ſeem to have occurred to him, nor, as far as I can find, to any other perſon, of bringing the uſe of it into actual practice. Many countries which contain no marl have ſufficient plenty of clay, and the farmer may likewiſe often procure lime or chalk at an eaſy

expence;

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* Young's Farmer's Tour through the Eaſt of England, Vol. IV. p. 403.

expence; the third ingredient, though of leſs importance, and not always found in marls, is to be met with in almoſt every country. Clay, by the addition of water, becomes ſoft and ductile; in this ſtate it may eaſily be mixed with any portion of chalk or of effete lime *, and a due quantity of ſand.

Let a floor of brick be laid, as for the preparation of mortar, on this let the clay be ſufficiently moiſtened, and then a proper quantity of calcareous earth and ſand be well incorporated with it by treading or by wooden ſtampers. When this is compleated, let it be thrown aſide, and another parcel compounded in the ſame manner †.

This

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* Lime is ſaid to be effete when it has recovered its air and water.

† Since this Eſſay was read before the Agriculture Society of Mancheſter, as I was travelling between Bradford and Halifax, I was driven, to take ſhelter from a violent ſtorm, into the ſtable of a labouring farmer, who was loading his cart with dung. The nature of his employment induced me to aſk him ſome queſtions relative to manures, and among others whether the country produced any marl. To this he anſwered in the negative, but informed me that clay was procurable, and that there was plenty of lime. On my telling him that from theſe ingredients he might make marl, I was not more ſurpriſed than pleaſed to find that he was well acquainted with the fact, and that he had actually

This may at firſt appear a difficult operation, but it will ſeem leſs ſo, when it is conſidered, that the quantity of clay and ſand together, in good marl, is not large, in ſome one-third, in ſome one-fifth, and in others not above one-ſixth or one-ſeventh of the whole maſs. Mechanical invention may doubtleſs point out methods of expediting and rendering the proceſs more convenient, and ſuch as may be within the reach of common farmers.

The clay uſed for this purpoſe ſhould be as free from metallic impregnations as poſſible. If it contain too great a quantity of iron, it will appear by the high degree of redneſs which it will acquire by calcination; if vitriolic or aluminous ſalts, the metallic or earthy parts may

be

ally executed what I had only ſurmiſed to be practicable. He ſaid, that about eight or ten years ſince, he had made artificial marl by throwing, alternately, layers of lime and clay, and then expoſing the heap, during the winter, to the weather; by which means it mouldered down, and became a ſufficiently uniform maſs. At the proper ſeaſon it was laid on the field, which produced, the enſuing year, a moſt excellent crop of wheat. When we conſider the ſolvent power which is ſo eminently poſſeſſed by quick-lime, this mode of producing an union between the calcareous and argillaceous earths will appear very feaſible, and will be attended with much leſs labour and expence than that which I had propoſed.

be diſcovered by adding to the water, in which the clay has been digeſted, a ſolution of ſalt of tartar or pot-aſh, which will precipitate the baſis of the ſalt, if of iron, in a brown ponderous powder; if aluminous, in a white or greyiſh earth.

The lime, that we may come nearer to nature in our imitation, ſhould not only be ſlaked, but be expoſed to the open air, and often turned for ſeveral months, that it may recover its air; for it requires a long ſeries of time before it recover the whole of which it has been deprived in calcination *.

When mixed it may, if thought proper, be formed into maſſes of a convenient bulk to be ſcattered on the ground, and heaped up to dry, previous to its being carried to the field. By this method, much may be ſaved in the weight of the carriage, if the marl be to be conveyed to

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* I find that Dr. Home thinks that lime produces little effect on vegetation till it is become effete. It may be known to have recovered its air by its no longer forming lime water, and by effervefcing violently with acids without growing hot. If, however, the method deſcribed in the laſt note be uſed, it will be ſufficient if the lime be fallen, without waiting for the recovery of its air, as this point will be acquired during the long time which the mixture is to be expoſed to the action of the atmoſphere.

to any diſtance from the place where the mixture is formed.

The marl may alſo be compounded of different proportions of clay, calcareous earth, and ſand, according to the nature of the land to which it is to be applied. To light or ſandy land, a greater quantity of clay will be proper; to ſtiff ſtrong land, more calcareous earth and ſand; and to very ſtrong clay it may be ſufficient to apply a mixture of calcareous earth and ſand with little or no clay.

Upon the whole may we not conclude, that lime, in moſt caſes, is a ſtronger manure, when it has recovered the air of which it has been deprived in calcination, than it is when brought freſh from the kiln; and that when procured for the purpoſes of agriculture, its efficacy and permanency will in general be increaſed, by mixing it, in its effete ſtate, with the other ingredients which enter into the compoſition of marl?

ESSAY XIII.

A Method of raiſing the Pine-Apple by Oak Leaves inſtead of Tanners Bark.

I Preſume that the leaves of the Oak abound with the ſame quality as the bark of the tree; therefore, the ſooner they are raked up after they fall from the trees, the better, as that quality will naturally decreaſe during the time they are expoſed to the weather. After being raked into heaps they ſhould immediately be carried to ſome place near the hot-houſes, where they muſt lie to *Couch*. I generally fence them round with charcoal-hurdles, or any thing elſe, to keep them from being blown about the garden in windy weather. In this place we tread them well, and water them in caſe they happen to have been brought in dry. We make the heap ſix or ſeven feet in thickneſs, covering it over with old mats, or any thing elſe, to prevent the upper leaves from being blown away. In a few days the heap will come to a ſtrong heat. For the firſt year or two that I uſed theſe leaves, I did not continue them in the heap longer than ten days or a fortnight; but in this I diſcovered a conſiderable inconvenience, as they ſettled ſo much when got into the hot-houſe as ſoon to require a ſupply. Taught by experience, I now let them remain in the heap for five or ſix weeks, by which time they are properly prepared for the hot-houſes. In getting them into the pine-pits, if they appear dry, we water them again, treading them in layers exceedingly well till the pits are quite full. We then cover the whole with tan to the thickneſs of two inches, and tread it well till the ſurface becomes ſmooth and even. On this we place the pine-pots in the manner they are to ſtand, beginning with the middle row firſt, and filling up the ſpaces between the pots with tan. In like manner we proceed to the next row till the whole be finiſhed; and this operation is performed in the ſame manner as when tan *only* is uſed.

After this the leaves require no farther trouble the whole ſeaſon through, as they will retain a conſtant and regular heat for twelve months without either ſtirring or turning; and if I may form a judgment from their appearance when taken out, (being always entire and perfect) it is probable they would continue their heat through a ſecond year; but as an annual ſupply of leaves is eaſily obtained, ſuch a trial is hardly worth the trouble of making.

After this the Pines will have no occaſion to be moved but at the ſtated times of their management, viz. at the ſhifting them in their pots, &c. when at each time a little freſh tan ſhould be added to make up the deficiency ariſing from the ſettling of the beds; but this will be inconſiderable, as the leaves do do not ſettle much after their long *Couching*. During the two firſt years of my practice I did not uſe any tan, but plunged the pine-pots into the leaves, and juſt covered the ſurface of the beds, when finiſhed, with a little ſaw-duſt, to give it a neatneſs. This method was attended with one inconvenience; for by the caking of the leaves they ſhrunk from the ſides of the pots, whereby they became expoſed to the air, and at the ſame time the heat of the beds was permitted to eſcape.

Many powerful reaſons may be given why Oak leaves (for I have not tried any other kinds) are preferable to tanners bark.

Firſt, They always heat regularly; for, during the whole time that I have uſed them, which is near ſeven years, I never once knew of their heating with violence; and this is ſo frequently the caſe with tan, that I affirm, and indeed it is well known to every perſon converſant in the management of the hot-houſe, that Pines ſuffer more from this one circumſtance, than from all the other accidents put together, inſects excepted. When this accident happens near the time of their fruiting, the effect is ſoon ſeen in the fruit, which always comes illſhaped and exceedingly ſmall. Sometimes there will be little or no fruit at all; therefore Gardeners who make uſe of tan *only* for their Pines, ſhould be moſt particularly careful to avoid an over-heat at that critical ſeaſon—the time of *ſhewing* fruit.

Secondly, The heat of Oak leaves is conſtant; whereas tanners bark generally turns cold in a very ſhort time after its furious heat is gone off. This obliges the gardener to give the tan frequent turnings in order to promote its heating. Theſe frequent turnings (not to mention the expence) are attended with the worſt conſequences; for by the continual moving of the pots backwards and forwards, the Pines are expoſed to the extremes of heat and cold, whereby their growth is conſiderably retarded; whereas, when leaves are uſed, the

Pines will have no occaſion to be moved but at the times of potting, &c.—The Pines have one particular advantage in this undiſturbed ſituation; their roots go through the bottoms of the pots and matt amongſt the leaves in a ſurprizing manner. From the vigour of the plants, when in this ſituation, it is highly probable that the leaves, even in this ſtate, afford them an uncommon and agreeable nouriſhment.

Thirdly, There is a ſaving in point of expence, which is no inconſiderable object in places where tan cannot be had but from a great diſtance, as is the caſe here, the article of carriage amounting to ten ſhillings for each waggon-load. Indeed, this was the principal reaſon that firſt induced me to make trial of leaves.

My laſt ground of preference is the conſideration that decayed leaves make good manure; whereas rotten tan is experimentally found to be of no value. I have often tried it, both on ſand and clay, alſo on wet and dry lands, and never could diſcover, in any of my experiments, that it deſerved the name of a manure; whereas decayed leaves are the richeſt, and, of all others, the moſt ſuitable for a garden.

den. But this muſt only be underſtood of leaves after they have undergone their fermentation, which reduces them to a true vegetable mould, in which we experimentally know that the food of plants is contained—but whether that food be *oil*, *mucilage*, or *ſalt*, or a combination of all three, I leave to philoſophers to determine. This black mould is, of all others, the moſt proper to mix with compoſt earth, and I uſe it in general for Pines, and almoſt for every thing that grows in pots. For flowers it is moſt excellent. The remainder of this vegetable mould may be employed in manuring the quarters of the kitchen-garden, for which purpoſe it is highly uſeful.

Leaves mixed with dung make excellent hot-beds—and I find that beds compounded in this manner preſerve their heat much longer than when made entirely with dung. In both caſes the application of leaves will be a conſiderable ſaving of dung; a circumſtance very agreeable, as it will be the means of preventing the conteſts, frequently obſerved in large families, between the ſuperintendant of the gardens and the directors of the huſbandry.

ESSAY XIV.

The Method of planting upon the Duke of Portland's Eſtates in Nottinghamſhire.

FEW Noblemen plant more than his Grace the Duke of Portland; and I may ſay, without vanity, none with greater ſucceſs. But as no man ſhould think of planting in the very extenſive manner that we do, before he is provided with well-ſtocked nurſeries, it may not be amiſs, before I proceed further, to give a ſhort ſketch of that neceſſary buſineſs, as alſo to deſcribe the ſoil and ſituation of our ſeat of planting.

The greateſt part of our plantations is on that ſoil, which in Nottinghamſhire is generally diſtinguiſhed by the name of Foreſt-land. It is a continuation of hills and dales. In ſome places the hills are very ſteep and high; but in general the aſcents are gentle and eaſy. The ſoil is compoſed of a mixture of ſand and gravel. The hills abound moſt with the latter, and the valleys with the former, as the ſmaller particles are, by the wind and rains, brought, from time to time, from the high grounds to the lower. It is on the hilly grounds we make our plantations, which in time will make the valleys of much greater value, on account of the ſhelter they will afford.

After his Grace has fixed on ſuch a part of this foreſt-land as he intends to have planted, ſome well-ſituated valley is choſen (as near the center of the intended plantations as may be) for the purpoſe of a nurſery: if this valley is ſurrounded with hills on all ſides but the ſouth, ſo much the better. After having allotted a piece of ground, conſiſting of as many acres as is convenient for the purpoſe, it is fenced about in ſuch a manner as to keep out all obnoxious animals. At either end of the nurſery are large boarded gates, as alſo a walk down the middle, wide enough to admit carriages to go through, which we find exceedingly convenient when we remove the young trees from thence to the plantations. After the fence is compleated, the whole is trenched (except the walk in the middle) about twenty inches deep, which work may be done for about three pounds ten ſhillings, or four pounds, per acre, according as the land is more or leſs gravelly: this work is beſt done in the ſpring when the planting ſeaſon is over. If, after the trenching, two or three chaldrons of lime be laid on an acre, the land will produce an excellent crop, either of cabbages or turnips, which, being eaten off by ſheep in the autumn, will make the land in fine order for all ſorts of tree-ſeeds: but as the Oak is the ſort of tree we cultivate in general, I ſhall confine myſelf particularly to our preſent method of raiſing and managing that moſt valuable ſpecies.—In the autumn, after the cabbage or turnips are eaten off, the ground will require nothing more than a common digging. So ſoon as the acorns fall, after being provided with a good quantity, we ſow them in the following manner: draw drills with a hoe in the ſame manner as is practiſed for peaſe, and ſow the acorns therein ſo thick as nearly to touch each other; leave the ſpace of one foot between row and row, and between every fifth row allow the ſpace of two feet for the alleys. While the acorns are in the ground, great care muſt be taken to keep them from vermin, which frequently will make great havock amongſt the beds, if not timely prevented. Let this caution ſerve for moſt other ſorts of tree-ſeeds.

After the acorns are come up, the beds will require only to be kept clean from weeds till they want thinning; and as the plants frequently grow more in one wet ſeaſon, where the ſoil is tolerably good, than in two dry ones, where the ſoil is but indifferent, the time for doing this is beſt aſcertained by obſerving when the tops of the rows meet. Our rule is to thin them then, which we do by taking away one row on each ſide the middlemoſt, which leaves the remaining three rows the ſame diſtance apart as the breadth of the alleys. In taking up theſe rows we ought to be anxiouſly careful neither to injure the roots of the plants removed, nor of thoſe left on each ſide. The reſt of the young Oaks being now left in rows at two feet apart, we let them again ſtand till their tops meet; then take up every other row, and leave the reſt in rows four feet aſunder, till they arrive to the height of about five feet, which is full as large a ſize as we ever wiſh to plant. In taking up the two laſt ſizes, our method is to dig a trench at the end of each row full two feet deep, then undermine the plants, and let them fall into the trench with their roots intire.

And here let me obſerve, that much, very much, of their future ſucceſs depends on this point of their being well taken up. I declare that

I ſhould form greater hopes from one hundred plants well taken up and planted, than from ten times that number taken up and planted in a random manner: beſides, the frequent loſs of the plants makes the worſt method the moſt expenſive.

But before I leave this account of our method of raiſing Oaks, I ſhall juſt beg leave to obſerve, that we are not very particular in the choice of acorns. In my own opinion it matters not from what ſort of tree the acorns are gathered, provided they are good; for although there ſeems to be a variety of the Engliſh Oak, in reſpect to the form of the leaf and fruit, alſo their coming into leaf at different ſeaſons, with ſome other marks of diſtinction, yet I am of opinion that they will all make good timber-trees if properly managed: it is natural to ſuppoſe that a tree will grow low and ſpreading in a hedge-row; on the contrary, it is very improbable that many ſhould grow ſo in a thick wood, where, in general, they draw one another up ſtraight and tall. And I have obſerved that the ſame diſtinctions hold good amongſt our large timber-trees in the woods, as in the low-ſpreading Oaks in the hedge-rows.

Though I have not as yet taken notice of any other ſort of tree but the Oak, yet we have a great regard for, and raiſe great quantities of Beech, Larch, Spaniſh Cheſnut, Weymouth Pine, and all ſorts of Firs, the Scotch excepted, as well as many other kinds, by way of thickening the plantations while young; amongſt which the Birch has hitherto been in the greateſt eſtimation, it being a quick-growing tree, and taking the lead of moſt other ſorts on our poor foreſt hills; and as we have an inexhauſtible ſpring of them in the woods, where they riſe of themſelves in abundance from ſeed, we at all times plant them plentifully of different ſizes. As to the Elm and Aſh, we plant but few of them on the foreſt, though we raiſe great quantities of both, but particularly the Aſh, which being an uſeful wood (but a bad neighbour amongſt the Oaks) we plant in places apart by itſelf.—I ſhall diſmiſs this ſubject concerning the management of our nurſeries, after ſaying a word or two relating to pruning: We go over the whole of the young trees in the nurſery every winter; but in this we do little more than ſhorten the ſtrong ſide-ſhoots, and take off one of all ſuch as have double leads.

Having thus pointed out the mode of forming and managing our nurſeries, I ſhall now proceed to the plantations.—The ſize of the plantations, at firſt beginning, muſt be in proportion to the ſtock of young trees in the nurſery; for to undertake to plant more ground than we have young trees to go through with for thick plantations, would turn to poor account on our foreſt-hills. We always plant thick, as well as ſow plentifully at the ſame time, provided it be a ſeaſon in which acorns can be had; ſo that all our plantations anſwer in a few years as nurſeries to ſucceeding plantations.

As to the form of the plantations they are very irregular: we ſometimes follow a chain of hills to a very great diſtance; ſo that what we plant in one ſeaſon, which perhaps is ſixty, eighty, and ſometimes an hundred acres, is no more than a part of one great deſign.

If the ground intended to be planted has not already been got into order for that purpoſe, it ſhould be fenced about at leaſt a twelvemonth before it is wanted to plant on, and immediately got into order for a crop of turnips. Two chaldrons of lime being laid on an acre will be of great ſervice, as it will not only be a means of procuring a better crop of turnips, but will bind the land afterwards, and make it fall heavy, which is of great uſe when it comes to be planted, as ſome of the foreſt-land is ſo exceedingly light as to be liable to be blown from the roots of the young trees after planting: therefore we find it to be in the beſt order for planting about two years after it has been plowed up from paſture, before the turf is too far gone to a ſtate of decay. It will be neceſſary to have a part of the turnips eaten off ſoon in the autumn, in order to get the ground into readineſs for early planting; for we find the forward planting generally ſucceeds the beſt.

After the turnips are eaten off, we plow the ground with a double-furrow trenching plow made for that purpoſe, which, drawn by ſix horſes, turns up the ground completely to the depth of twelve or thirteen inches. This deep plowing is of great ſervice to the plants at the firſt, and alſo ſaves a great deal of trouble in making the holes. After the plowing is finiſhed, we divide the ground into quarters for the planting by ridings. It will be a difficult matter to deſcribe the laying out the ground for this purpoſe, eſpecially where there is ſuch a variety of land as we have on the foreſt: much depends on the taſte of the perſon employed in this office. Between the hills, towards the outſides of the plantations, we frequently leave the ridings from ſixty to an hundred yards in breadth, and contract them towards the middle of the woods, to the breadth of ten or twelve yards; and on the tops of the hills where there are plains, we frequently leave lawns of an acre or two, which makes a pleaſing variety.

In ſome of them we plant the Cedar of Libanus at good diſtances, ſo as to form irregular groves; and this ſort of tree ſeems to thrive to admiration on the foreſt-land. On the outſides of the woods, next to the ridings, we plant Evergreens, as Hollies, Laurels, Yews, Junipers, &c. and theſe we diſpoſe of in patches, ſometimes the ſeveral ſorts entire, at other times we intermix them for variety; but not ſo as to make a regular ſcreen or edging. Our deſign in the diſtribution of theſe plants, is to make the outſides of the woods appear as if ſcalloped with Evergreens intermixed ſometimes with rare trees, as the *Liriodendron Tulipifera*, or Virginian Tulip-tree, &c.

After the ground is laid out into quarters for planting, we aſſign certain parts to Beech, Larch, Spaniſh Cheſnuts, &c. Theſe we plant in irregular patches here and there throughout the plantations, which, when the trees are in leaf, has the moſt pleaſing effect, on account of the diverſity of ſhades; eſpecially in ſuch parts of the foreſt where four, five, and ſometimes more of the large hill-points meet in the ſame valley, and tend, as it were, to the ſame center.

After thoſe patches are planted, or marked out for that purpoſe, we then proceed to the planting in general. We always begin with planting the largeſt young trees of every ſort, and end our work with thoſe of the ſmalleſt ſize. Were we to proceed otherwiſe, the making a hole for a larger-ſized tree, after the ſmall ones are thick planted, would cauſe the greateſt confuſion.

Birch is generally the ſort of tree we make our beginning with, which we find will bear to be removed with great ſafety, at the height of ſix or ſeven feet, tho' we commonly plant rather under than at that ſize. This ſort of tree we are always ſupplied with from our plantations of five or ſix years growth.—But before I proceed to the taking them up, it will be proper to inform you, that in the planting ſeaſon we divide our hands into four claſſes, which we term Takers-up, Pruners, Carriers, and Planters: and here I ſhall deſcribe the ſeveral methods of doing this work.

Firſt, in taking up we have the ſame care to take up with good roots in the plantations, as was recommended in the nurſery, though we cannot purſue the ſame method; but in both places, ſo ſoon as the plants are taken up, we bed them in the ground in the following manner: Dig a trench at leaſt fifteen inches deep, and ſet the young trees therein with their tops aſlant, covering their roots well as we go along, and almoſt half way up the ſtem of the plants, with the earth that comes out of a ſecond trench, which we fill in the like manner, and ſo proceed on till we have a load, more or leſs, in a heap, as may be convenient to the place from whence they were taken. In our light ſoil this trouble is but little, and we always have our plants ſecure, both from their roots drying, and their ſuffering by froſt. We have a low-wheeled waggon to carry them from the heaps, where they are bedded, to the pruners,

ners, and generally take two loads every other day. When they arrive, the Planters, Pruners, &c. all aſſiſt to bed them there, in the ſame manner as before deſcribed. We have a portable ſhed for the Pruners to work under, which is alſo convenient for the reſt of the work people to take ſhelter under in ſtormy weather. From the above heaps the plants are taken only ſo faſt as they are wanted for pruning, which work we thus perform: Cut off all the branches cloſe to the ſtem, to about half the height of the plant, ſhortening the reſt of the top to a conical form in proportion to the ſize of the plant; and in pruning of the roots, we only cut off the extreme parts that have been bruiſed by the taking up, or ſuch as have been damaged by accident, wiſhing at all times to plant with as much root as can be had.

As ſoon as they are pruned they are taken to the Planters by the Carriers, who are generally a ſet of boys, with ſome of the worſt of the labourers. The Planters go in pairs; one makes the holes, and the other ſets and treads the plants faſt, which work they commonly do by turns. In making of the holes we always take care to throw out all the bad ſoil that comes from the bottom. If the planting be on the ſide of a hill, we lay the bad ſoil on the lower ſide of the hole, ſo as to form a kind of baſon; for without this care our plants would loſe the advantage of ſuch rains as fall haſtily. We at all times make the holes ſufficiently large, which is done with great eaſe after our deep plowing.

Before we ſet the plant, we throw a few ſpadefuls of the top ſoil into the hole, ſetting the plant thereon with its top rather inclining to the weſt; then fill up the hole with the beſt top ſoil, taking care that it cloſes well with the roots, leaving no part hollow. When the hole is well filled up, one of the planters treads and faſtens the tree firmly with his feet, while his partner proceeds to make the next hole.

The faſtening a tree well is a material article in planting; for if it once becomes looſe, the continued motion which the wind occaſions is ſure to deſtroy the fibres as faſt as they are produced, which muſt end in the deſtruction of the plant, if not prevented. It is to guard againſt this inconvenience that we take off ſo much of the top, as has been deſcribed in the article of pruning.

We plant about three or four hundred Birches of the large ſize on an acre, and nearly the ſame number of the firſt-ſized Oaks. We alſo plant here and there a Beech, Larch, Spaniſh Cheſnut, &c. excluſive of the patches of the ſaid ſorts of trees before planted. We then proceed to plant plentifully of the ſecond and leſſer-ſized Oaks; and laſt of all a great number of the ſmall Birches, which are procured from the woods at about three ſhillings or three ſhillings and ſixpence per thouſand: theſe we remove to the ſucceeding plantations after the term of five or ſix years. Of the ſeveral ſizes of the different kinds of trees we generally plant upwards of two thouſand plants upon an acre of land, all in an irregular manner.

After the planting is finiſhed we then ſow the acorns (provided it be a ſeaſon that they can be had) all over the plantation, except amongſt the Beech, Larch, &c. in the aforeſaid patches. Great care ſhould be taken to preſerve the acorns intended for this purpoſe, as they are very ſubject to ſprout, eſpecially ſoon after gathering: the beſt method is to lay them thin in a dry airy place, and give them frequent turnings. We ſow theſe acorns in ſhort drills of about a foot in length, which work is done very readily by two men; one with the acorns, the other with a hoe for the purpoſe of making the drills and covering the ſeed.

We are of opinion that the plants produced from theſe acorns will at laſt make the beſt trees; however, I will not pretend to ſay how that may be, as the Oaks tranſplanted ſmall grow equally well for a number of years: but it is probable that a tree, with its tap-root undiſturbed, may, in the end, grow to a much larger ſize.

After the whole is finiſhed to a convenient diſtance round the Pruners, we then remove their ſhed to a ſecond ſtation, and there proceed in the like manner; and ſo on till the whole be finiſhed.

It would be well to get the planting done by the end of February, eſpecially for trees of the deciduous kind; but from the diſappointments we meet with, occaſioned by the weather, we are ſometimes detained to a later ſeaſon.

I have ſeveral times made trial of twelve or fourteen kinds of American Oaks ſent over to his Grace in great quantities. I ſowed them in the nurſery, and alſo in the beſt and moſt ſheltered parts of the plantations. In both places they come up very plentifully; but I now find that ſeveral of the ſorts will not ſtand the ſeverity of our winters, and thoſe that do make ſo ſmall a progreſs as to promiſe no other encouragement than to be kept as curioſities.

Towards the end of April, when the ground is moiſt, it will be of great ſervice to go over the whole plantations, and faſten all ſuch trees as are become looſe ſince their planting. After this, nothing more will be required till the month of June, when we again go over the whole with hoes, cutting off only the tall-growing weeds; for the ſooner the ground gets covered with graſs, in our light ſoil, ſo much the better.

I own there is ſomething ſlovenly in the appearance of this method, and on ſome lands I would recommend keeping the ground clean hoed for ſome time at firſt, as alſo planting in rows, which in that caſe would be neceſſary. More than once I have tried this method on our foreſt-hills, and always found, after every hoeing, that the ſoil was taken away by the ſucceeding winds into the valleys.

Beſides this inconvenience, the reflection of our ſandy ſoil is ſo very great, that we find the plants ſtand a dry ſeaſon much better in our preſent method than in the former: and whoever fancies that graſs will choak and deſtroy ſeedling Oaks, will, after a few years trial, find himſelf agreeably miſtaken. I have even recommended the ſowing the poorer parts of the hills with furze or whin-ſeed as ſoon as they are planted. We have ſometimes permitted the furze to grow in the plantations by way of ſhelter for the game, which, though it ſeems to choak and over-grow the Oaks for ſome time, yet, after a few years, we commonly find the beſt plants in the ſtrongeſt beds of whins. This ſhews how acceptable ſhelter is to the Oak whilſt young, and experience ſhews us that the Oak would make but a ſlow progreſs on the foreſt-hills for a number of years at the firſt, were it not for ſome kind nurſes; and the Birch ſeems to anſwer that purpoſe the beſt, as I have already obſerved.

The ſeveral ſorts of Fir-trees, from appearance, ſeem to promiſe a greater ſhelter; but, on the foreſt-land, they do not grow ſo faſt as the former; and what is worſe, the Oak will not thrive under them, as they do immediately under the Birch.

Where a plantation is on a plain, a ſcreen of Firs for its boundary is of ſingular uſe; but the ſituation of the foreſt-land denies us this advantage.

We continue to cut down the tall-growing weeds two or three times the firſt ſummer, and perhaps once the next, or ſecond ſeaſon after planting, which is all that we do in reſpect to cleaning. The next winter after planting we fill up the places with freſh plants where they have miſcarried, after which there is little to be done till about the fourth or fifth year, by which time the ſmall-ſized Birch and ſeedling Oaks will be grown to a proper ſize for tranſplanting. In the thinning of theſe due care muſt be had not to take too many away in one ſeaſon; but, being properly managed, there will be a ſupply of plants for at leaſt half a dozen years to come.

About the ſame time that the leſſer-ſized Birch want thinning, the large ones will require to have their lower branches taken off, ſo as to keep them from injuring the Oaks; and this is the firſt profit of our plantations, the Birch-wood being readily bought up by the broom-makers. This pruning we continue as often as required, till the Birches are grown to a ſufficient ſize to make rails for fencing: we then cut them down to make room for their betters.

By this time the Oaks will be grown to the height of twelve or fourteen feet, when they draw themſelves up exceedingly faſt. Each plant ſeems as it were in a ſtate of ſtrife with its neighbour, and in a ſtrict ſenſe they are ſo, and on no other terms than life for life; and he whoſe fate it is to be once over-topped, is ſoon after compelled to give up the conteſt for ever.

After the Birches are cut down there is nothing more to be done but thinning the Oaks from time to time, as may be required, and cutting off their dead branches as frequently as may be neceſſary. We are very cautious in doing the former, knowing well that if we can but once obtain length of timber, time will bring it into thickneſs; therefore we let them grow very cloſe together for the firſt fifty years.

And here it may not be improper to obſerve the progreſs the Oak makes with us, by deſcribing them in two of our plantations, the one of twenty-eight, the other of fifty years growth. In the former they are in general about twenty-five or twenty-ſix feet in height, and in girth about eighteen inches; the trees in the latter, planted in 1725, are ſomething more than ſixty feet in height, and in girth a little above three feet; and theſe trees are in general about fifty feet in the bole, from which you will eaſily conceive the ſmallneſs of their tops, even at this age.

It would be a difficult matter to deſcribe their farther progreſs with any degree of certainty, therefore let it ſuffice to make this laſt obſervation on them in their mature ſtate.

I ſhould have before obſerved to you, that in both the aforeſaid, as well as in all the young plantations, the Spaniſh Cheſnut keeps an equal pace, or rather out-grows the Oak, but it is doubtful whether ever they will arrive at the ſame ſize; for the largeſt of our Spaniſh Cheſnuts, which have much the appearance of old trees, do not girth more than twelve or fourteen feet, which is nothing in compariſon to ſome of our large Oaks, which girth from twenty-five to thirty feet: indeed ſome of them a great deal more. For inſtance, that remarkable tree called the Greendale Oak, (from its growing in a valley of that name near Welbeck) which, in the year 1724, had a hole cut through its body large enough to admit a coach to go through.

I ſhall omit deſcribing the preſent ſtate of this piece of antiquity, as two fine views of it are given in Dr. Hunter's late edition of Mr. Evelyn's Silva, from which may be ſeen, notwithſtanding the uncommon ſize of the lower part of the tree, that it never has contained any great quantity of timber; I mean in compariſon with ſeveral of our largeſt Oaks, ſome of which contain, in their tower-like trunks, between ſeven and eight hundred ſolid feet of timber, excluſive of their ſtately tops; and ſome of their large branches are even like trees themſelves.

END of the FIRST VOLUME.

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